Monitoring and Assessment of Wolf-Ungulate Interactions and Population Trends within the Greater Yellowstone Area, Southwestern Montana, and Montana Statewide

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INTRODUCTION

Montana Fish, Wildlife, and Parks (FWP) and the Ecology Department of Montana State University – Bozeman (MSU) initiated a cooperative investigation focusing on wolf-ungulate population interactions in the Greater Yellowstone Area of southwestern Montana. Private landowners, the National Park Service (NPS), and the U. S. Fish and Wildlife Service (USFWS) are important partners in this effort. Here, I summarize objectives and preliminary results of these investigations. Other summaries of this cooperative project are available at the following website location:
http://www.homepage.montana.edu/~rgarrott/wolfungulate/index.htm and
http://www.montana.edu/wwwbi/staff/creel/creel.html#Creel's%20Homepage

I will also discuss FWPs more extensive, but less intensive monitoring of wolf and ungulate population characteristics throughout Montana in relation to GYA studies.

The elk herds of the Yellowstone, Gallatin, Madison and the Gravelly-Snowcrest complex represent a highly valued resource. The re-introduced and expanding wolf populations in the same Greater Yellowstone Area (GYA), likewise, command national and statewide attention. The potential impact of wolf predation on ungulate populations is a highly controversial issue, both within the general public and the scientific community. Our investigations will monitor trends in population parameters for these elk herds and newly established wolf packs across a range of geographic sites and different environmental conditions. The best estimate as of December 2005 is that there were 1,020 wolves in at least 71 breeding packs (134 total packs) in Montana, Idaho and Wyoming (U.S. Fish and Wildlife Service et al. 2006). This is the 6th consecutive year with more than 30 breeding pairs for this area. The total included an estimated 325 wolves in the Greater Yellowstone Recovery area and an estimated minimum of 256 wolves and 19 breeding pairs within the State boundaries of Montana (U.S. Fish and Wildlife Service et al. 2006). In the southern Montana experimental area, there were 27 packs, 9 of which met the breeding pair criteria. In northwestern Montana, there were 19 packs, 10 of which met the breeding pair criteria (Sime et al. 2006). Wolves have reached the numerical and distributional goals for recovery. As Montana, in conjunction with Wyoming, Idaho, and the USFWS, prepares for the de-listing effort of the Gray Wolf, it is imperative that we gain a better understanding of how these two important resources interact. This information will be especially pertinent to decisions affecting potential adjustments in hunter harvest prescriptions for ungulate populations in Montana.

Wolves are well established within Yellowstone National Park (YNP) and have been dispersing from the Park and establishing new packs in adjacent areas. Elk populations are a highly valued resource in this area and FWP has collected data on these elk populations going back in some cases to the 1920s. FWP administrative Region 3, surrounding YNP, provides approximately 50% of Montana elk harvest and hunter days of recreation. Land ownership, land use, vegetation communities and environmental conditions vary across this area. Elk harvest management strategies also vary and reflect different migratory patterns, harvest availability, and habitat of these elk herds. Our study approach allows comparisons to be made among the demographics of elk herds subjected to wolf predation, but no hunting, herds affected by both wolf predation and hunting, and elk herds affected by hunting, but little or no wolf predation.

Expansion of study outside the GYA is necessary to find areas with no impact by wolf predation. It is also important to document ungulate population size, trend, and characteristics for areas without wolves prior to wolves becoming established. By working in areas with differing ecological characteristics, we can make comparisons to identify factors that most impact wolf-elk dynamics. For comparative purposes, it is also important that wolves have been present in northwestern Montana, near Glacier National Park since 1979 and breeding pairs have been present there since about 1985-86. Because FWP has historical data on elk and other ungulates, we can make pre- and post-wolf comparisons among sites.

The objectives of this report are to: 1) Summarize findings of research to date on wolf-ungulate interactions in the GYA funded and conducted by this project; 2) incorporate more extensive findings of research in the GYA by other projects for comparative purposes and; 3) incorporate extensive data throughout Montana on wolves, other predators, and ungulates for comparative purposes and to help determine data needs for further research.

STUDY SITES

Intensive Winter Studies by MSU Students

Intensive studies by MSU of the effect of wolves on ungulates during winter occur at three sites (Figure 1). These sites are the Gallatin Canyon (Dr. Scott Creel and John Winnie, Jr. - finished), (Dr. Scott Creel and Dave Christianson – field work completed); Lower Madison (Dr. Robert Garrott and Justin Gude - finished), Dr. Robert Garrott and Jamin Grigg –field work nearly finished and; Madison-Firehole (Dr. Garrott and students). The Madison-Firehole site is a separately funded study, but because Dr. Garrott is a cooperator on our studies, its results can be used for comparisons. This is especially important because the non-migratory elk herd associated with this area remains in YNP yearlong and is not hunted by humans.

Extensive Studies by FWP

FWP collects population data on elk and other ungulates in the Gallatin Canyon and Lower Madison sites during winter as well as at other times of the year. This data also includes information on numbers and composition of hunter kill. As part of the comparative nature of the study, FWP collects information on ungulate populations in the adjacent Northern Yellowstone area near and north of Gardiner, Montana and in the Gravelly-Snowcrest Mountain complex in the Ennis and Dillon areas (Figure 2). FWP has long-term, pre-wolf data for these areas also. For help with interpretation, FWP will also use ungulate population data from other widely scattered areas in Montana to include areas with little or no influence by wolves at this time.

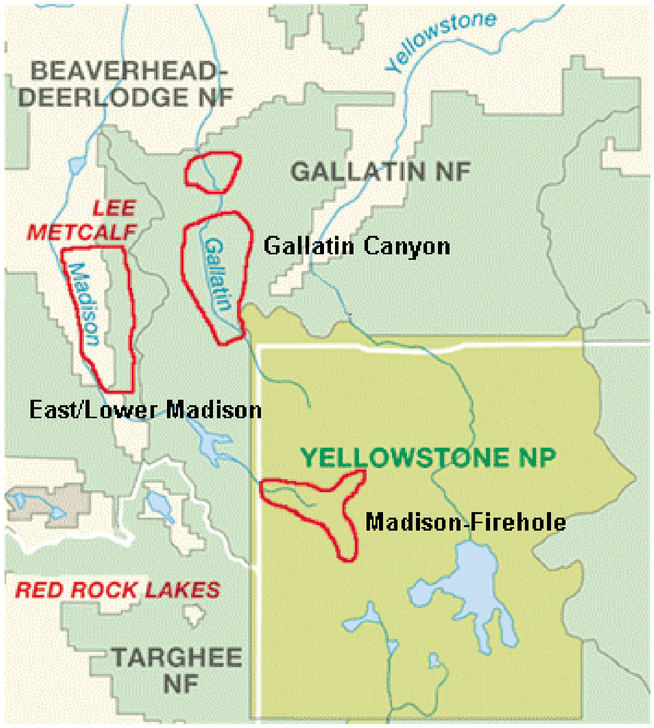

Figure 1. Location of Gallatin Canyon, Lower Madison, and Madison-Firehole student Study areas.

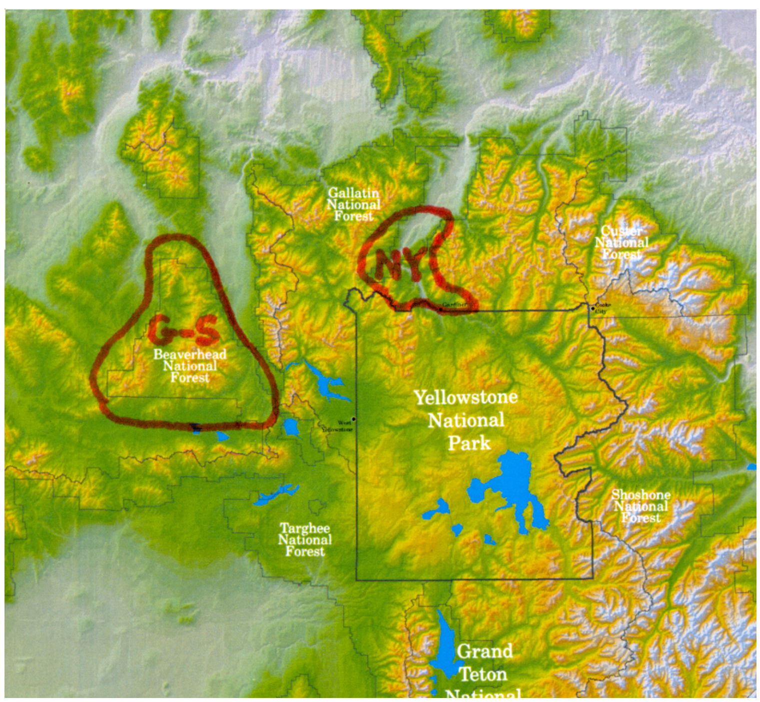

Figure 2. Location of Gravelly-Snowcrest (G-S) and Northern Yellowstone (NY) study areas.

OBJECTIVES

Intensive Winter Studies - Gallatin and Lower Madison study areas (emphasis may vary between the areas).

1.) Determine kill rate by wolves on ungulates and sex and age composition of that kill, especially for elk.
2.) Determine the effects of this kill on elk population structure and numbers in comparison to hunter kill.
3.) Determine the factors that influence wolf predation on elk.
4.) Determine if wolf predation adds to or compensates for other kinds of elk mortality.
5.) Determine the behavioral and geographical responses (grouping, movements, distribution) of elk to wolf predation.
6.) Determine the physiological costs (nutrition, condition, calf production and survival) to elk of these responses to predation risk.

Extensive Studies by FWP

1.) FWP will provide estimates of elk population trend by continuing aerial counts of elk populations in the Gallatin Canyon and Lower Madison study areas. FWP will add an early winter helicopter flight in the Gallatin Canyon to the one previously conducted in late winter.
2.) Additionally FWP will continue cooperative aerial trend counts of the Northern Yellowstone elk population and trend counts for the Gravelly-Snowcrest populations. FWP will also use aerial elk and other ungulate trend counts from other areas in Montana for comparison with the intensive study areas.
3.) FWP will add mid-summer flights to the Gallatin, Madison and Gravelly-Snowcrest elk study areas and other areas of Montana to aid in determining timing of elk calf mortality.
4.) FWP will conduct mid-summer, early winter and late winter classifications of elk sex and age composition to aid in determining timing of elk calf mortality and the population composition from which wolves and hunters select their prey.
5.) FWP will run hunter check stations and use the statewide hunter harvest questionnaire to determine number and composition of hunter kills.
6.) FWP will capture and mark elk with VHF and GPS radio transmitter collars in the various study areas to help determine yearlong elk distribution, causes of mortality of adults and distribution of elk as affected by wolves and hunters.
7.) FWP will collect various data on the Gallatin Canyon, Lower Madison and Gravelly-Snowcrest study areas to help determine elk pregnancy rates, nutritional status, and stress levels.

PRELIMINARY FINDINGS

Gallatin Canyon Study

Project personnel have 2 manuscripts accepted and 3 submitted for review to professional Journals. These manuscripts provide more detailed findings than the summaries provided here and are listed below.

Scott Creel and John A. Winnie, Jr. (2005). Responses of Elk Herd Size to Fine-Scale Spatial and Temporal Variation in the Risk of Predation by Wolves (*Animal Behavior* 69:1181-1189).

Scott Creel, John Winnie, Jr., Bruce Maxwell, Ken Hamlin and Michael Creel. (2005). Elk Alter Habitat Selection as an Antipredator Response to Wolves (*Ecology 86:3387-3397*).

John Winnie, Jr. and Scott Creel. (*submitted*). Behavioral Responses of Elk to the Threat of Wolf Predation (*Animal Behavior*).

John Winnie, Jr., D. Christianson, B. Maxwell, and S. Creel. (*submitted*). Elk decision-making rules are simplified in the presence of wolves. *(Behavioral Ecology and Sociobiology).*

Dave Christianson and S. Creel. (*submitted*). A review of environmental factors affecting winter elk diets. *(Journal of Wildlife Management).*

Pregnancy Rate

Combined for 2002-2004, 56 (91.8%) of 61 adult females were pregnant as determined by Pregnancy Specific Protein B in blood samples. Excluding a non-pregnant yearling and 18 ½-year-old, 56 (94.9%) of 59 adult females were pregnant.

Pregnancy rate estimates based on progesterone concentrations in fecal samples collected after mid-March have not been finalized. These estimates are also complicated by the necessity to estimate, based on classifications, percent of the sample from adult females. Preliminary results indicate lower pregnancy rates than determined by blood samples of captured adult females.

Survival/Mortality of Radio-collared Adult Elk

Fifty-seven adult female and 14 adult male elk provided information for determination of survival/mortality from 16 February 2002 through 31 December 2005. Elk that died within a week of capture or those for which the transmitter did not function were excluded. Because 26 elk were equipped with GPS collars with programmed “drop-off” dates, annual samples by year were problematic. Average monthly mortality rates, which are multiplied to estimate average annual rates over the period are reported here (Table 1). The months of March-December are based on 4 years and January and February are based on 3 years of data. Annualized rates of mortality for adults were relatively low compared to the adjacent Gravelly-Snowcrest elk population (Hamlin and Ross 2002). Wolf predation was the cause of 2 of 14 mortalities (Table 2). These relatively small samples indicated 1.1% and 6.2%

annualized mortality due to wolf predation for adult females and adult males, respectively. Bear predation accounted for 3.2% annualized mortality of adult females. Hunter harvest accounted for 3.2% annualized mortality of adult females and 18.8% annualized mortality of adult males.

Table 1. Annualized monthly survival/mortality rates for adult elk, Gallatin Canyon study, 2002-2005.

Month	Ad. Female Mean S/M(E. M.)[a]	Ad. Male Mean S/M(E. M.)[a]
June	1.00 / 0.00 (104)	1.00 / 0.00 (18)
July	1.00 / 0.00 (100)	1.00 / 0.00 (17)
August	1.00 / 0.00 (98)	1.00 / 0.00 (17)
September	1.00 / 0.00 (98)	0.941 / 0.059 (17)
October	1.00 / 0.00 (86)	1.00 / 0.00 (16)
November	0.988 / 0.012 (85)	0.833 / 0.167 (12)
December	1.00 / 0.00 (84)	1.00 / 0.00 (10)
January	0.970 / 0.030 (67)	1.00 / 0.00 (9)
February	0.984 / 0.016 (62)	1.00 / 0.00 (9)
March	1.00 / 0.00 (119)	1.00 / 0.00 (23)
April	0.983 / 0.017 (117)	0.956 / 0.044 (23)
May	0.965 / 0.035 (114)	1.00 / 0.00 (22)
Mean Annual Survival / Mortality	**0.895 / 0.105**	**0.749 / 0.251**

[a] Mean Survival/Mortality (Elk Months)

Table 2. Causes of mortality of radio-collared adult elk on the Gallatin Canyon study area, 2002-2005.

Cause of Mortality	Adult Females	Adult Males	Total
Hunter-kill archery		1	1
Hunter-kill general season	1	2	3
Hunter-kill late season	2		2
Wolf-kill	1	1	2
Grizzly bear-kill	1		1
Unk. spp. Bear-kill	2		2
Natural/Broken leg	1		1
Vehicle Collision	1		1
Unknown	1		1
Hunting	**3**	**3**	**6 (42.9%)**
Predation	**4**	**1**	**5 (35.7%)**
Other and Natural	**3**		**3 (21.4%)**

Survival/Mortality of Transmitter Equipped Newborn Elk Calves

During May and June 2005, 29 newborn elk calves were captured within the Gallatin study area and equipped with eartag-radio transmitters. During summer, 13 certain and 2 probable deaths occurred. Two transmitters went on mortality mode between 5 July and 30 September, but ceased to function by the time the sites were investigated therefore death or its cause could not be verified. Of the 13 verified deaths, 9 were the result of bear predation (2 grizzly and 7 unverified species), 3 were probable bear predation, and 1 was the result of coyote or domestic dog predation (D. Christianson, pers. comm.). For this small one-year sample, wolf predation was not recorded for newborn elk calves during summer.

Thirteen deaths (44.8%), all predation, occurred between 20 May and 23 June. If the 2 other transmitters with mortality signals were deaths (likely), total summer mortality rate was 51.7% for the sample of elk calves in the Gallatin Canyon.

Wolf Kill Rates and Selection of Prey During Winter

Over a 3-month period during winter 2000-2001, when number of wolf-days on the study area could be determined, 24 wolf-killed elk were found by radio-tracking over 283 wolf-days. This was a kill rate of 8.48 kills/100 wolf-days or 0.085 elk kills per wolf-day (http://homepage.montana.edu/~rgarrott/wolfungulate/gallatin_canyon.htm).

During 2001-2003, 42 definite and 9 probable wolf-killed elk and 2 possible wolf-killed moose were found during winter (J. Winnie, Jr., pers. comm.). During December 2003 – May 2006, an additional 61 wolf-killed elk and 2 wolf-killed moose were found during winter (D. Christianson pers. comm.). The more recent data is preliminary and may change. Of 107 elk for which sex and age could be determined, 58 (54.2%) were adult males, 32 (29.9%) were calves, and 17 (15.9%) were adult females. These proportions were biased toward adult males and calves compared to expected proportions (Creel and Winnie 2005). The home range of the Chief Joseph pack almost entirely overlapped the major bull wintering area in the Daly-Tepee-Lodgepole drainages of the Gallatin Canyon, which likely contributed to the observed sex/age ratio of the kill.

Of dead elk examined during December 2003-May 2006, 61 were wolf-kills, 30 died as a result of vehicular collisions, 15 were of unknown cause, 3 were bear-kills, 1 was a winter-kill, and 1 was hung up in a fence (D. Christianson pers. comm.).

Impacts of Wolves on Elk Behavior, Habitat Use, and Other Indirect Impacts

Creel and Winnie (2005) reported significant indirect impacts of wolves on elk in the Gallatin Canyon study, including group size, habitat use, and possibly proportion males in groups. They found that elk group sizes were smaller and elk were closer to (or in) cover when wolves were present in a drainage than when they were not detected. These responses suggested that elk foraging and forage composition of their diet might be affected as well.

Further studies began to determine if foraging changes occur, and if so, is nutrition and possibly calf production and survival affected? Fieldwork on this aspect of the study was completed during spring 2006 and results will be presented when the student completes his thesis.

Also, data collected thus far indicate that the presence of wolves could impact success by hunters as elk change behavior, location and habitat use from the traditional patterns that hunters have learned. Behavioral changes also have implications to commercial outfitters on USFS lands. Because outfitters cannot move their licensed area of use to other drainages, they may be significantly impacted depending upon the location where wolves establish territories.

Lower Madison Study

Project personnel have had 2 manuscripts published in professional Journals. These manuscripts provide more detailed findings than the summaries provided here and are listed below. Also, annual reports for the Lower Madison study can be viewed at: http://www.homepage.montana.edu/~rgarrott/wolfungulate/reports.htm

Justin A. Gude, Robert A. Garrott, John Borkowski, and Fred King. (*2006).* Prey Risk Allocation in a Grazing Ecosystem. (*Ecological Applications 16:285-298*).

Robert A. Garrott, Justin A. Gude, Eric J. Bergman, Claire Gower, P. J. White, and Kenneth L. Hamlin. (*2005*). Generalizing Wolf Effects Across the Greater Yellowstone Area: a cautionary note. (*Wildlife Society Bulletin 33:1245-1255*).

Capture, Marking, and Telemetry

On 16 and 17 February 2005, we captured 32 adult females, 1 female calf, and 4 adult male elk in the upper Madison Valley between Indian Creek on the north and Quake Lake on the south (most on Sun Ranch) using chemical immobilization by darting from a helicopter. The calf died soon after, probably related to capture trauma. Remaining elk included 19 adult females with GPS transmitter collars, 17 adult females with VHF transmitter collars, and 4 adult males with VHF transmitter collars. On 20 and 21 February 2006, we captured 29 adult female and 2 adult male elk within the same area as in 2005 using chemical immobilization by darting from a helicopter. All 29 females were equipped with GPS transmitter collars and the 2 males were equipped with VHF transmitter collars. GPS radio-transmitter collars were scheduled to make a "location fix" at 30-minute intervals.

Captured females were generally younger (71.4% less than 9-years-old) than those captured in the Gallatin (60.0% less than 9-years-old, but older than hunter-killed females in the Gravelly-Snowcrest Mountains (88.4% less than 9-years-old (Hamlin and Ross 2002).

Also, on 16 February 2005, we captured 2 male wolves in the Sun Ranch area using chemical immobilization by darting from a helicopter. One was equipped with a GPS transmitter scheduled for fixes every 3 hours and 1 was fitted with a VHF transmitter. This pack contained a previously marked (VHF) adult female wolf. On 20 February 2006, we recaptured the GPS collared male wolf by darting from a helicopter and replaced his GPS transmitter collar with a new GPS collar scheduled to "blow-off" in mid-February 2007. On 8 May 2006, Mike Ross captured 2 adult female wolves by leg-hold traps on the adjacent Wall Creek Wildlife Management Area and fitted them with VHF radio-transmitter collars and on 25 May 2006, he captured a yearling male wolf on the Sun Ranch by trapping and fitted it with a VHF transmitter.

Of the 20 GPS radio-telemetry collars deployed on female elk during 2005, one was a probable capture-related mortality, one malfunctioned and "blew-off" after only a month, and the remaining 18 functioned until programmed "blow-off" time in late January 2006. We have not been able to relocate one collar, but retrieved the 17 others and they performed exceptionally well. Sixteen of the transmitter obtained from 95-98% of all possible locations during the 49-week period, averaging about 16,500 locations each. One transmitter started malfunctioning after July, obtaining only about 55% of possible locations after that for a total of about 13,000 locations. Together, about 280,000 locations were obtained for the 17 female elk during mid-February 2005 through late January 2006.

The wolf GPS radio-transmitter also worked very well, recording about 2,130 locations during the year, or about 76% of possible "fixes". Jamin Grigg, the student on the Madison study, will conduct the analysis of the interactions of elk and wolves based on GPS locations (Figure 3).

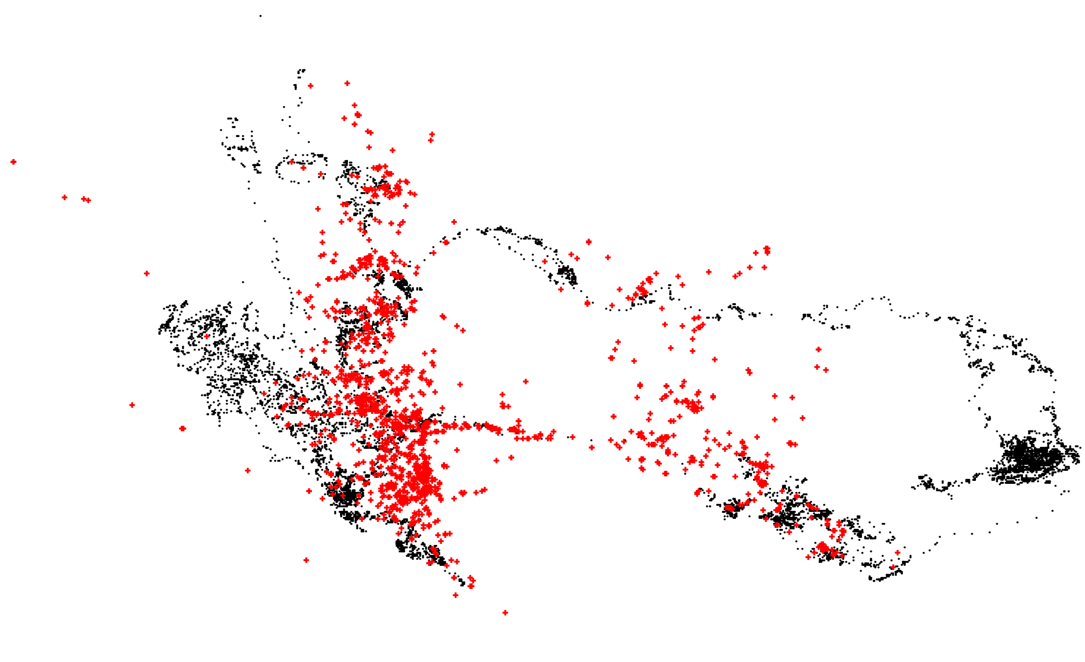

Figure 3. Example of overlay of GPS locations for one elk (black dots - 30 minute fix interval) with GPS locations for one wolf (red pluses - 3 hour fix intervals) over a 49-week period.

Pregnancy Rates

Combined for 2005-2006, 49 (83.1%) of 59 adult females were pregnant as determined by Pregnancy Specific Protein B in blood samples. Two (33.3%) of 6 yearlings, 44 (93.6%) of 47 2-10 year-olds, and 3 (50%) of 6 females 11-years or older were pregnant. Forty-seven (88.7%) of females 2-years or older were pregnant. Pregnancy rate for females 2-years and older were higher in 2005 (93.1%) than 2006 (83.3%), but sample sizes were small for both years.

Mortality/Survival of Radio-transmitter Collared Elk

No mortalities of transmitter-collared elk in this population due to wolf predation occurred during February 2005 – April 2006. One of 31 adult females was a hunter-kill during the general season and 2 of 4 adult males were hunter-kills during the general season. Four of the newborn calves captured within the Gallatin study area wintered in the Madison Valley. After moving west, across the Madison River in early April, one of these calves was killed by a mountain lion near the Wall Creek Wildlife Management Area.

Wolf Kill Rates and Selection of Prey

Gude and Garrott (2003) reported wolf-kill rates of 11.2 elk/100 wolf-days (0.112/WD) during winter 2001-02 and 13.8 elk/100 WD (0.138/WD) during winter 2002-03. These rates are higher than others reported in the literature, including those reported earlier here for the Gallatin Canyon and those reported in the Northern Range (Smith et al. 2004b) and Madison-Firehole (Dr. R. Garrott, pers. comm.) areas of Yellowstone National Park. For those areas, reported wolf-kill rates of elk were about 6 elk/100 WD or slightly higher. Wolf-kill rates were also variable throughout winter during each year and among years (Gude and Garrott 2003).

During 6 winters, 2001-02 through 2005-06, elk comprised 87.9% of ungulate prey of wolves, mule deer 9.1%, and pronghorn 3.0% (Table 3, Gude and Garrott 2001, 2002, 2003, Fuller and Garrott 2004, Grigg and Garrott 2005, and Grigg and Garrott pers. comm.). Of wolf-killed elk, calves comprised 68.1% of the total, while comprising about 15% of the population, indicating selection of calves by wolves.

Numbers of kills found during 2004-05 are not comparable to other years because only one person conducted fieldwork during that winter compared to 2 people working during other winters.

Table 3. Species and sex/age composition of definite or probable wolf-killed ungulates on the Lower Madison study area, winters 2000-01 through 2005-06[a].

Year	Elk				
	Total	Adult Males	Adult Females	Calves	Unknown
2000-01	56	7	13	36	-
2001-02	17	-	2	15	-
2002-03	43	2	14	27	-
2003-04	26	2	4	20	-
2004-05	14	-	6	8	-
2005-06	48	2	13	33	-
Total	**204 (87.9%)[b]**	**13 (6.4%)[c]**	**52 (25.5%)[c]**	**139 (68.1%)[c]**	**-**
	Mule Deer				
	Total	Adult Males	Adult Females	Fawns	Unknown
2000-01	5	-	-	3	2
2001-02	5	1	2	1	1
2002-03	6	1	2	3	-
2003-04	1	-	-	1	-
2004-05	0	-	-	-	-
2005-06	4	-	-	4	-
Total	**21 (9.1%)[b]**	**2**	**4**	**12**	**3**
	Pronghorn				
	Total	Adult Males	Adult Females	Fawns	Unknown
2000-01	1	-	1	-	-
2001-02	0	-	-	-	-
2002-03	4	-	1	1	2
2003-04	2	2	-	-	-
2004-05	0	-	-	-	-
2005-06	0	-	-	-	-
Total	**7 (3.0%)[b]**	**2**	**2**	**1**	**2**
Total Ungulates	**232**				

[a] Two wolf-killed coyotes were also found during both winter 2000-01 and 2004-05.
[b] Figure in (parentheses) is percent of total ungulates.
[c] Figure in (parentheses) is percent of total elk.

Impacts of Wolves on Elk Behavior, Habitat Use, and Other Indirect Impacts

For the Lower Madison study area, type of habitat and human hunting impacted elk group size, but there was no evidence that wolf predation risk influenced elk group size (Gude and Garrott 2003, Gude et al. 2005). There was evidence that wolf predation risk influenced elk distribution (Gude et al. 2005). That is, after a wolf predation event, elk moved from the area. This may affect distribution of elk grazing and browsing pressure compared to pre-wolf patterns (Gude et al. 2005).

Extensive Studies - Greater Yellowstone Area

Trends in Elk Population Size

Gallatin Canyon Study Area

Counts of the Gallatin elk herd have been conducted for longer than anywhere else in Montana (Fig. 4). Unfortunately, one of the periods without data is the recent pre-wolf period of 1986-1995 (Fig. 4). An interpretive problem that has always occurred is that a portion of the population migrates through the Taylor Fork drainage up over the Madison crest to winter on slopes along the east side of the Madison River. These numbers vary among years and also the timing of their movements varies. Thus, depending on the weather and timing of the early winter flight, elk that spend most of winter in the Madison Valley may or may not be included in the count. This probably accounts for much of the year-to-year variation seen in Figure 4. For example, almost all of the elk migrating to the Madison Valley to winter were likely in the Gallatin Canyon during the 1995 flight (Fig. 4). To smooth this variation, I have presented average counts by time period in Figure 6. Average counts were 2,078 elk for 1929-1948, 1,599 elk for 1953-1962, 1,640 elk for 1964-1972, 1,532 elk for 1975-1985, and 1,102 for 1996-2006 (Fig. 4).

There appear to be clear differences among average population levels for 3 periods: prior to 1949, from 1953-1985, and 1996-2005 (Fig. 4). It is possible that delaying the start of the late hunt until early January after 1989 (compared to early-mid-December prior to 1990) may have allowed some movement of elk over the Madison divide that were kept “staged” in the Gallatin drainage by the pressure of the late hunt. However, recent data on elk movements indicates that they move whenever they want and can cross the divide within a day, or overnight. Also, calf survival has been unusually low in recent years (see later), which could also have contributed to the recent average population decline. For whatever reason, recent population counts have averaged 28% lower than pre-1985.

Harvests of antlerless elk have been at historically low levels from 2000 to the present, averaging 73 antlerless elk annually compared to 226 antlerless elk from 1986-1996. The implied hunter harvest of about 5% of the preseason antlerless elk should not have contributed significantly to a population decline.

This elk population is one of the few in Montana with a recent decline in population counts compared to past years (MFWP, Wildlife Division, 2005). Although we can track this population for periodic changes to long-term average level, it will be difficult-to-impossible to relate influencing variables to year-to-year changes in elk counts.

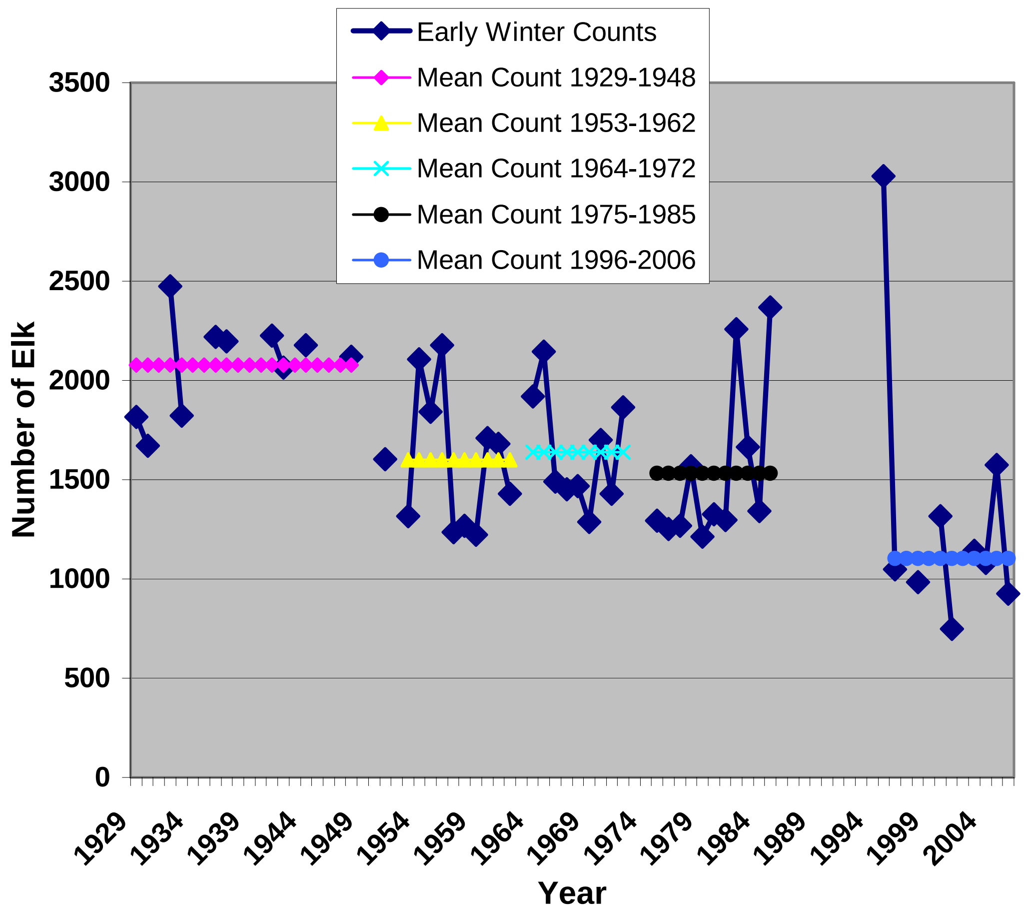

Figure 4. Early-winter aerial counts of elk in the Gallatin Canyon study area, 1929-2006.

Lower Madison Valley Study Area

Aerial counts of elk during winter along the east face of the Madison Range indicate a population that has increased over the years (Fig. 5). The population segment from Indian Creek to Quake Lake (red squares in Fig. 5) includes the Lower Madison study area. Many of these elk spent winter 2003-2004 north of the study area and information for the separate segments could not be presented for spring 2004 (Fig. 5). More intensive information from ground observations indicated that near the end of winter, about the same number of elk used the Lower Madison study area as in recent previous years (Fuller and Garrott 2004). Observed interchange between this herd and the elk population on the Wall Creek Wildlife Management Area (WCWMA) make it difficult to determine numbers on either area based on 1 flight. The increased numbers observed during 2006 may be related to using a helicopter instead of a fixed-wing aircraft for counts and the possible presence of WCWMA elk on the area at time of the flight.

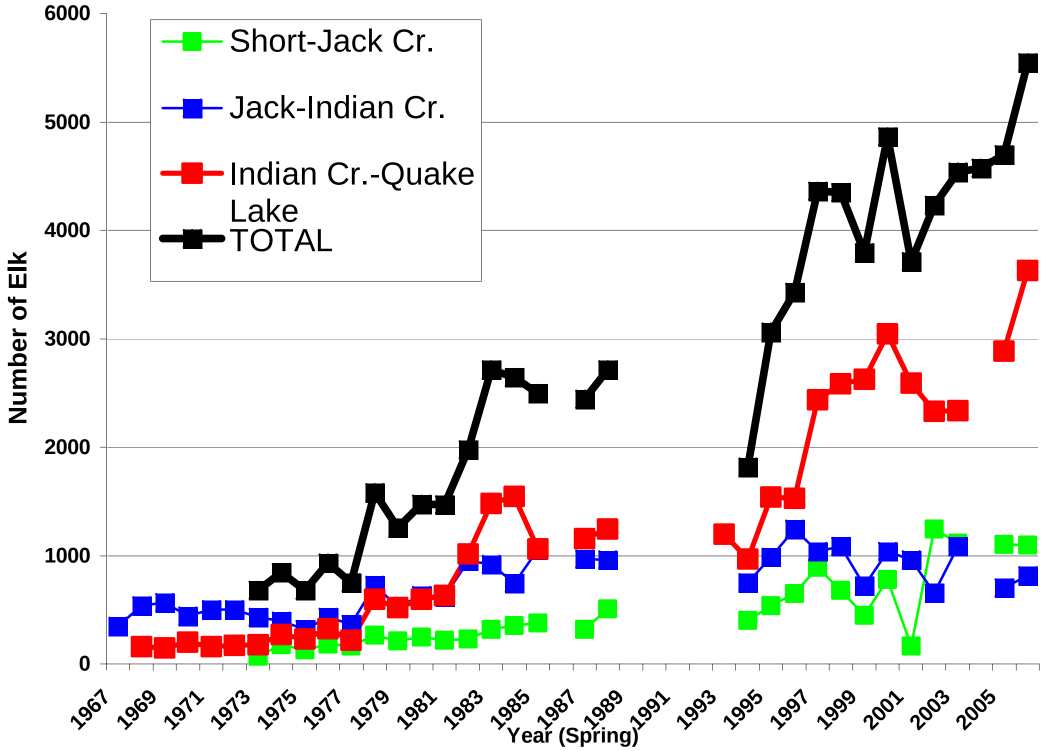

Figure 5. Aerial counts of elk during mid-to-late-winter along the east face of the Madison Range, 1967-2006. Indian-Quake Lake area includes the Lower Madison study area.

Gravelly-Snowcrest Area

The Gravelly-Snowcrest elk population is one of the largest and more heavily hunted elk populations in Montana, averaging about 8,000-9,000 counted elk post-season in recent years (Hamlin and Ross 2002, Fig. 6). Harvest rates have been high, averaging 16% for adult females during 1984-1996 and occasionally reaching more than 20% during some years (Hamlin and Ross 2002). These high harvest rates have maintained a relatively stable population since about 1987, though a series of poor harvest years recently may have resulted in an increased population recently (Fig. 6). The 2 major sub-populations show differing trends (Fig. 7) with the Wall Creek WMA wintering population continuing to increase and the Blacktail-Robb-Ledford WMA population showing stability since 1990 and decline in the last 2 years. The Wall Creek WMA population receives the lightest harvest pressure of the 2 areas (Hamlin and Ross 2002).

These populations occur just to the west of the Lower Madison study area and the furthest from YNP of our studied elk populations in the Greater Yellowstone Area (Fig. 2).

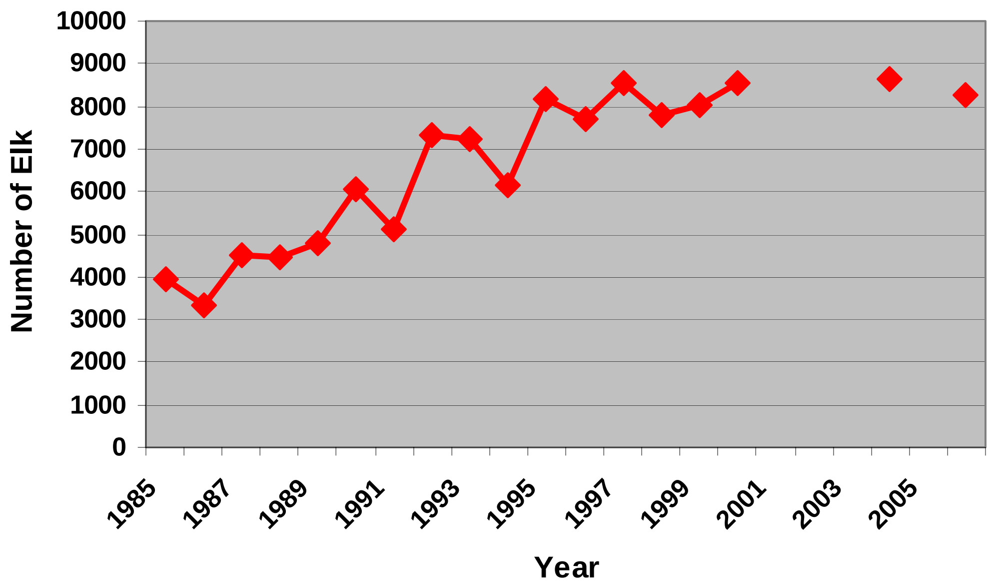

Figure 6. Aerial trend counts of elk during winter for the entire Gravelly-Snowcrest complex, 1985-2006.

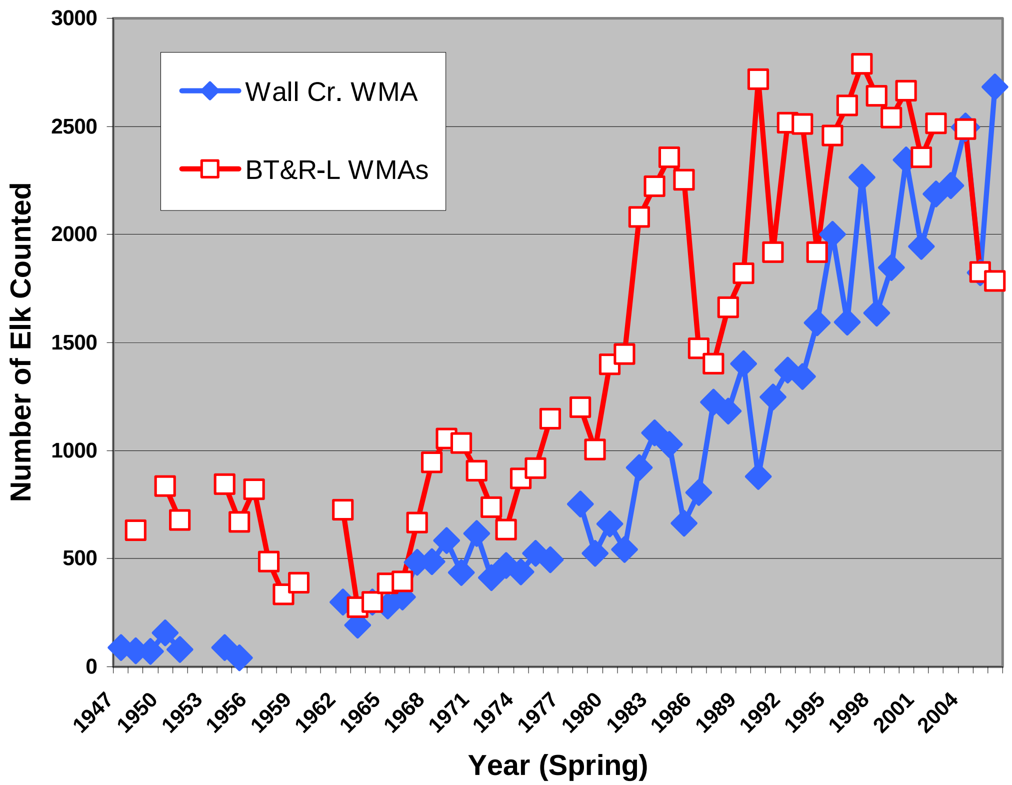

Figure 7. Aerial trend counts of elk during winter on the Wall Creek Wildlife Management Area and Blacktail and Robb-Ledford Wildlife Management Areas in the Gravelly-Snowcrest Mountains, 1947-2006.

Madison-Firehole Study Area (Dr. Robert Garrott & students)

From 1965-2002, the estimated fall population of elk in the Madison-Firehole region of YNP fluctuated around a stable equilibrium of 541 elk (Fig. 8). Recently, the population trend has broken the equilibrium trendline downward, coincident with a downward trend in calf survival (Fig. 8, Dr. R. Garrott, pers. comm.). Estimated fall population level for 2004 and 2005 are still being constructed, but estimates of spring numbers for 2005 and 2006 indicate further decline (Fig. 8, Dr. R. Garrott, pers. comm.) This elk population remains yearlong in YNP and is not subject to human hunting.

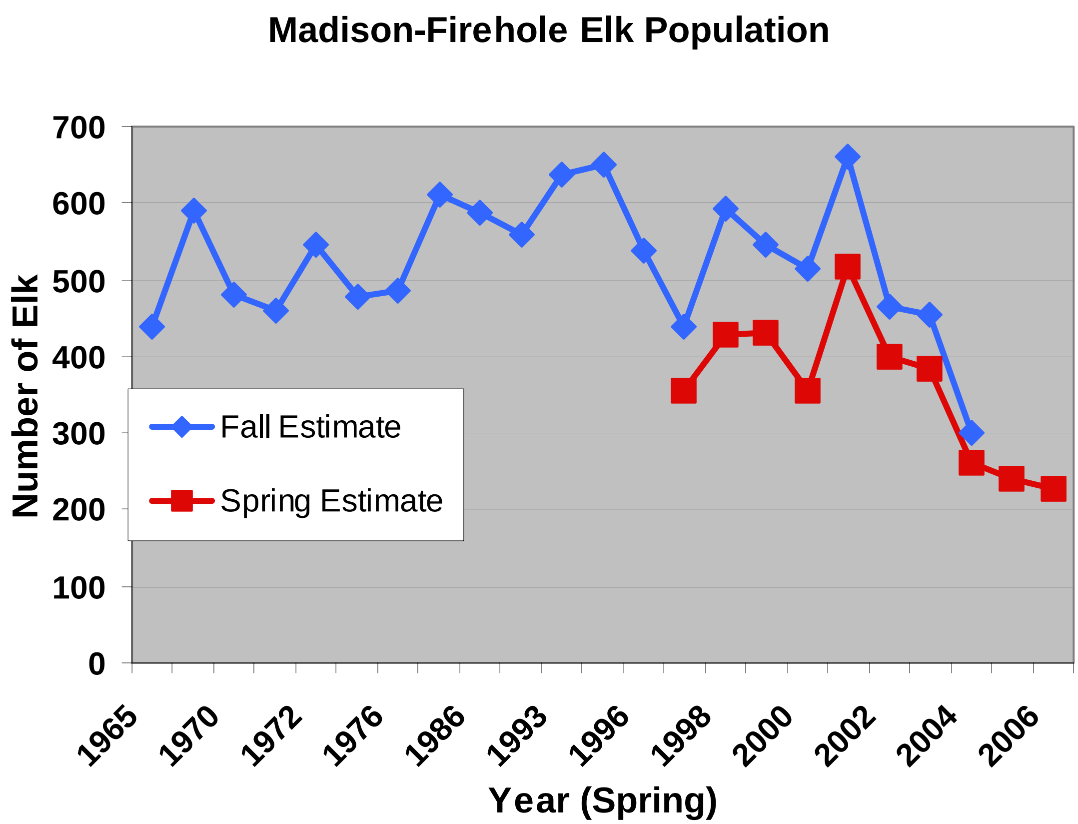

Figure 8. Estimated fall population of elk in the Madison-Firehole study area, 1965-2006 (courtesy Dr. Robert Garrott, MSU).

Northern Yellowstone Elk Population

Numbers of elk counted during cooperative censuses of the Northern Yellowstone elk herd are presented as uncorrected counts (Fig. 9) and data for some years such as 1988-89 and 1990-91 represent poor counting conditions. Counted numbers ranged from a low of 3,172 in 1967-68 at the end of reduction efforts to a high of 19,045 during 1993-94. The count in December 2004 was 9,545 elk. No early winter count was accomplished during 2005-06, but the late-winter count of elk winter north of YNP (Fig. 10) and an increase in calf recruitment indicated that at least a small increase in population numbers was likely.

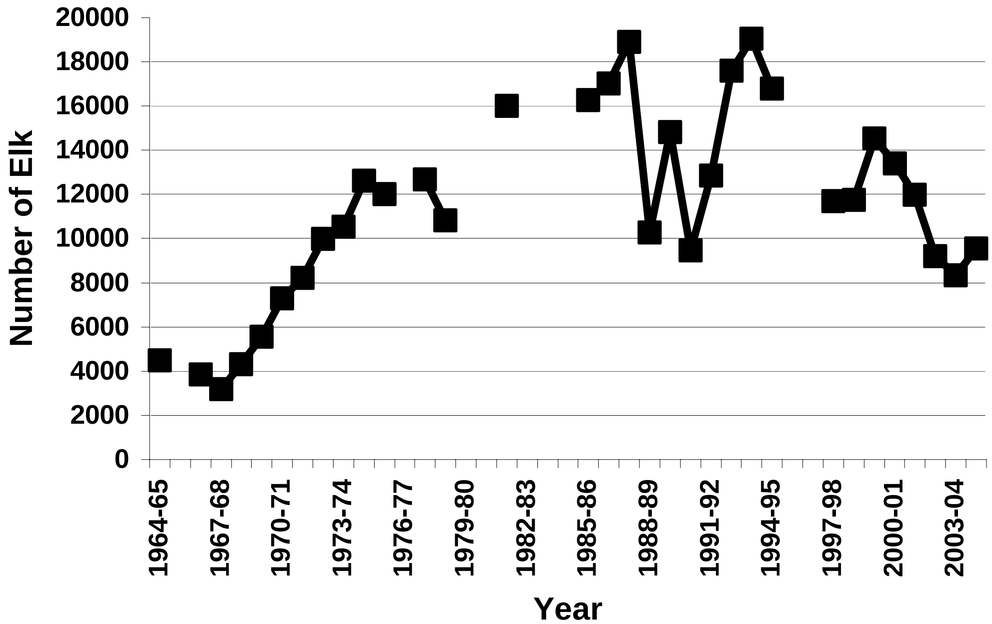

Figure 9. Trend in number of elk counted in early winter during the cooperative Northern Yellowstone elk counts, 1964-65 through 2004-05.

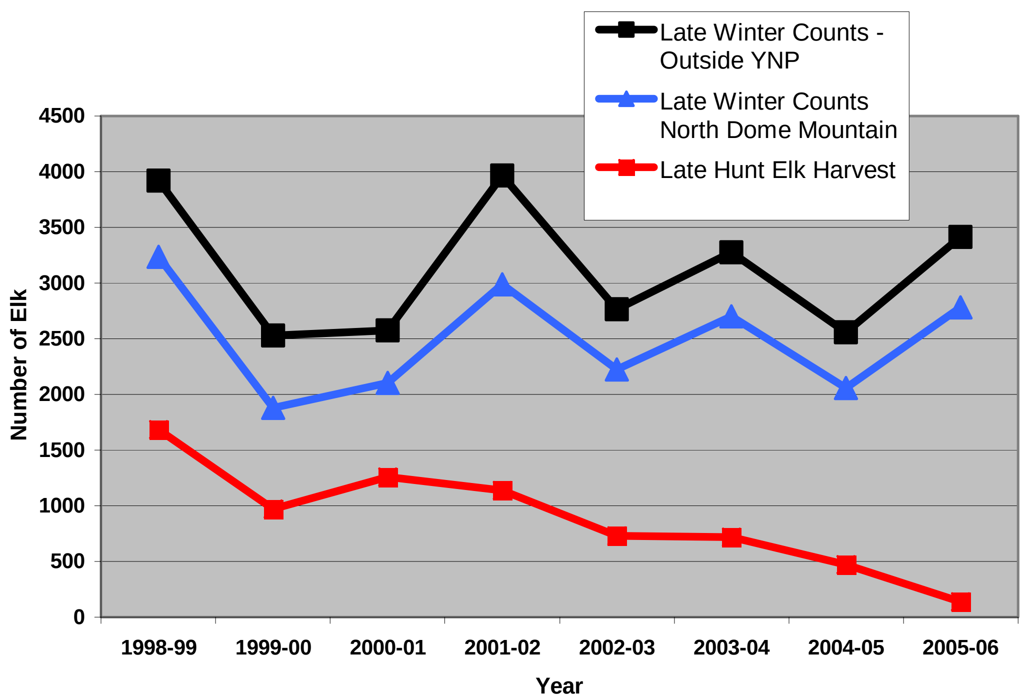

Figure 10. Trend in numbers of elk counted north of Yellowstone National Park during late-winter 1999-2006 and late hunt elk harvest.

A portion of the Northern Yellowstone elk population winters outside YNP and that proportion varies annually, especially with weather conditions during winter (Fig. 11). The numbers presented in Figure 11 represent early winter and the numbers of elk that winter north of YNP sometimes increase from these levels during mid to late winter. Generally, the number of elk harvested during the late season has reflected the number wintering north of YNP during early winter (Fig. 11), but harvest has declined relative to numbers wintering north of YNP since 2002 (Fig. 11).

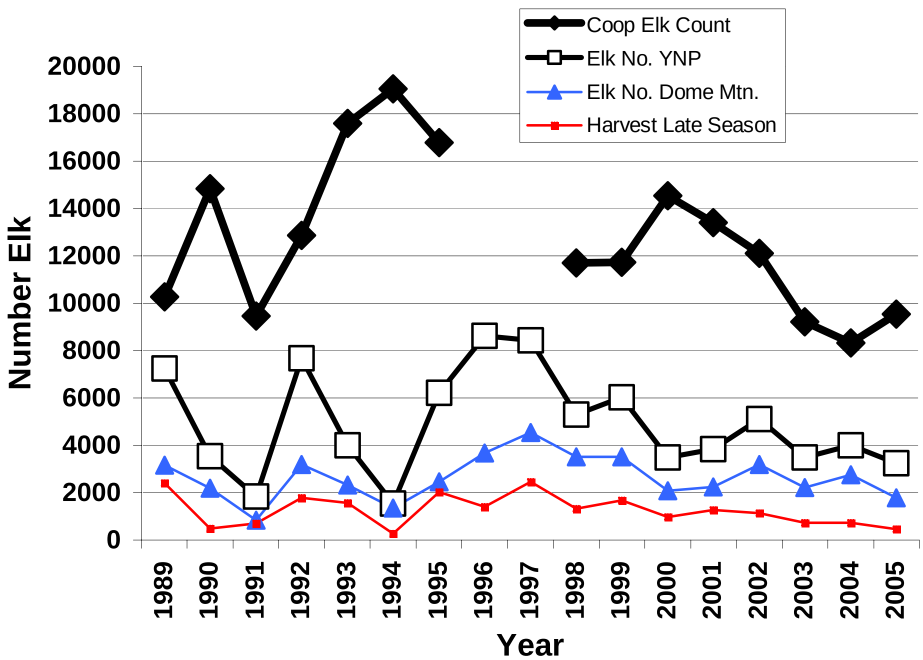

Figure 11. Number of elk counted during early winter for the Northern Yellowstone elk herd, including partitioning by numbers observed outside YNP, north of Dome Mountain, and number of elk harvested during the late season, 1988-89 through 2004-05.

In many analyses, the Northern Yellowstone elk herd is treated as one homogenous population. Based on movements, area used, and mortality risks, however, there are at least 3 segments, perhaps more. One segment remains in YNP yearlong, one almost always winters north of YNP, and the wintering location of another large segment varies with weather conditions. Thus, different segments of the population are subjected to different levels of hunting mortality and wolf and other predator density and mortality. Hunting mortality only occurs for those elk wintering north of YNP and this mortality level varies not only with the numbers of permits issued, but with weather conditions that affect the proportion of the elk population wintering north of YNP.

Since 2000, the early winter trend in number of total elk counted and number of elk counted inside YNP is significantly down while the number counted north of YNP (subject to hunting) has been relatively stable (Figs. 10 and 12). Thus, it appears that the recent decline in numbers of elk counted has been disproportionately among the portions of the elk population not subject to hunting, or variably subject to hunting. Relatively mild winters since 1996-97 have resulted in a relatively lower proportion of the elk population being subjected to late season harvests. The segment of the Northern Yellowstone elk population showing the greatest decline in numbers (Fig. 12) appears to be the one subject to the least hunting mortality and the greatest wolf density and predation pressure.

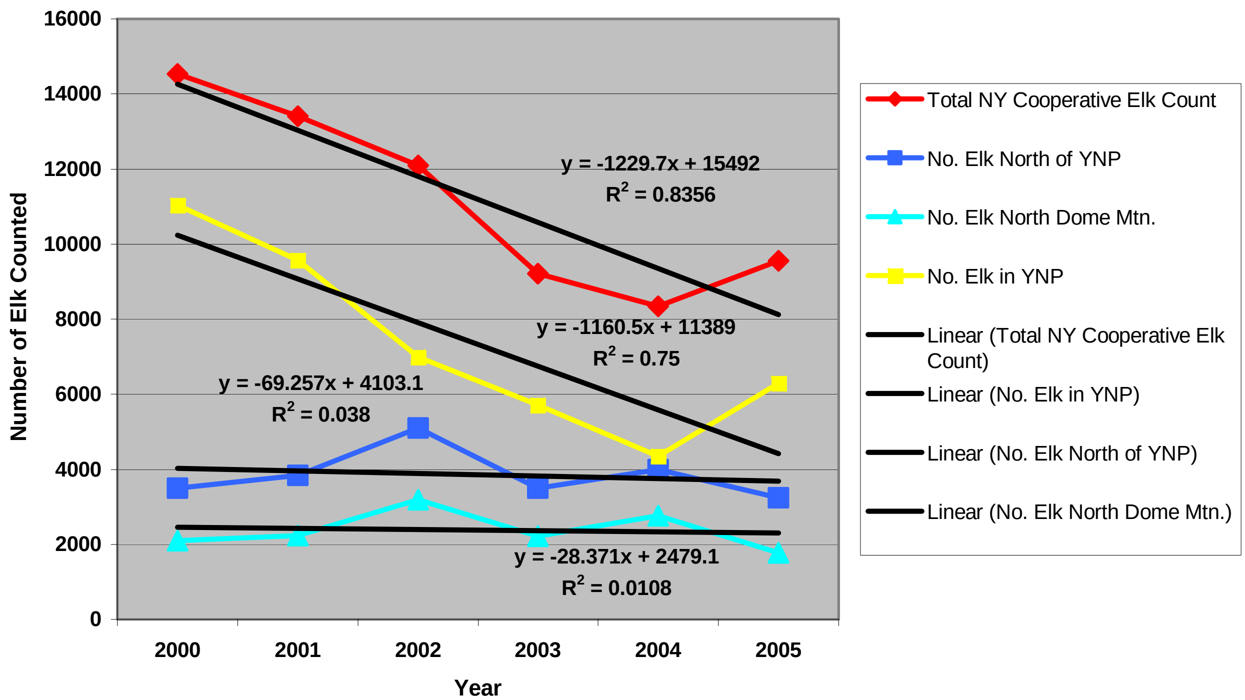

Figure 12. Number of elk counted and trend line for various segments of the Northern Yellowstone elk herd, 2000-2005.

Elk Recruitment Trends

Age Classifications and Calf Survival

Mid- to late- winter calf:100 cow ratios have declined from long-term averages since 1995 in the Gallatin, Madison, Gravelly-Snowcrest, Northern Yellowstone, and Madison-Firehole areas (Figs. 13 and 14). This decline coincides with the re-introduction of wolves to Yellowstone National Park, but began before those wolves could have impacted areas such as the Gravelly-Snowcrest Mountains. Little impact would have occurred for the other populations for the first few years of reintroduction.

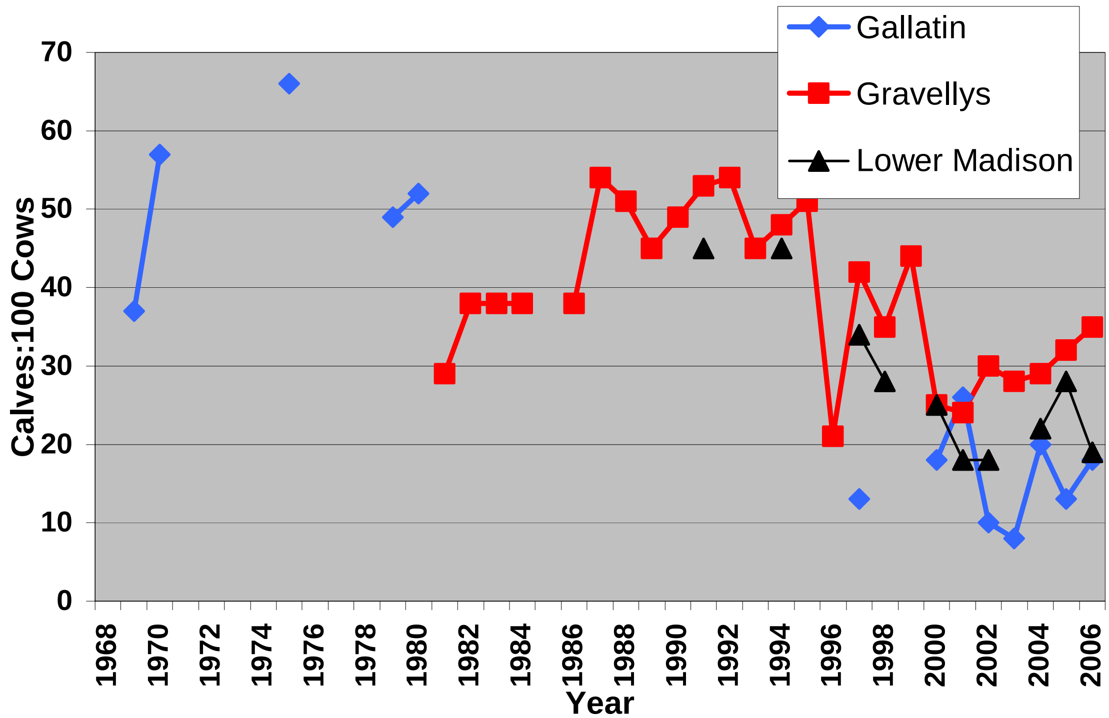

Figure 13. Early-mid winter calf:100 cow ratios in the Gallatin, Madison and Gravelly-Snowcrest elk populations, 1968-2006.

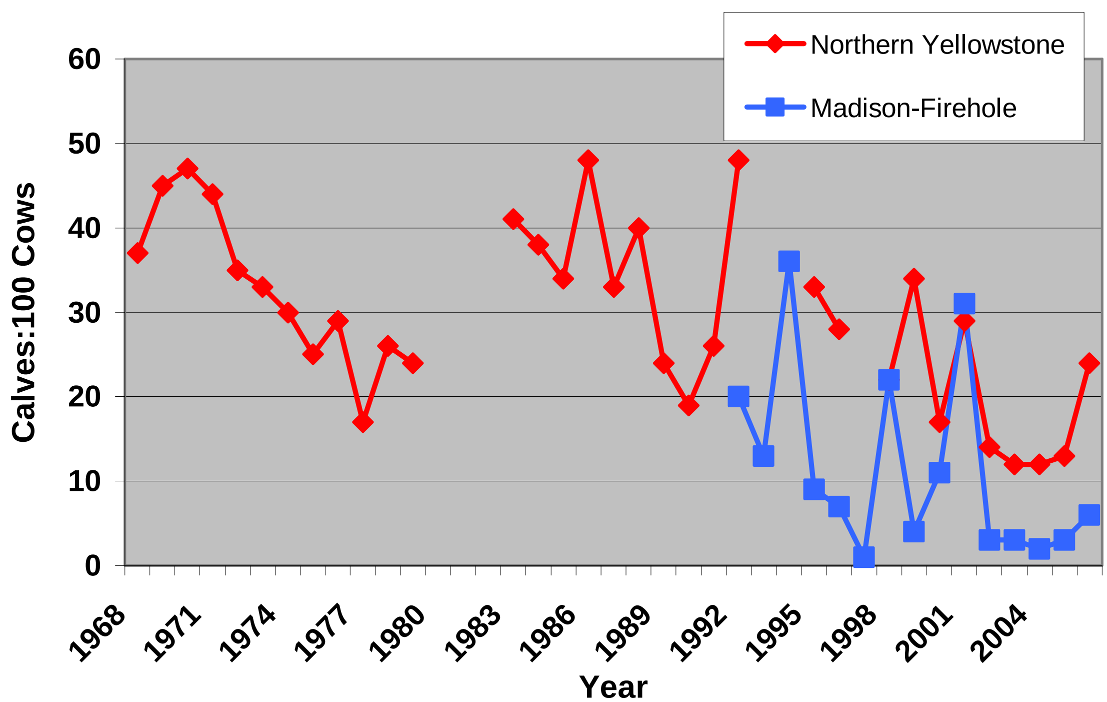

Figure 14. Late-winter calf:100 cow ratios, Northern Yellowstone and Madison-Firehole elk populations, 1968-2006.

Classification data also indicate that calf:100 cow ratios have been substantially below average by mid-summer (late July) in both the Gallatin and Gravelly-Snowcrest areas since about 1995 (Fig. 15). This decline has been more severe in the Gallatin drainage than the Gravelly-Snowcrest Mountains (Fig. 15), but in both areas calf:100 cow ratio was low before much wolf predation would be expected. Elk calf production/survival has been unusually low prior to winter, when much of the intensive research on mortality has occurred.

Although not at past levels, calf survival has been increasing in the Gravelly-Snowcrest Mountains since a low in 2001 (Figs. 13 and 15). In 2005-06, recruitment of calves in the Northern Yellowstone population increased to about 24 calves:100 cows, the first time since 2002 recruitment has been above 20:100 (Fig. 14). In the Gallatin however, additional calf mortality has occurred during late winter in the last 2 years. Early/late winter calf:100 cow ratios were 13.5:100 / 8.5:100 in 2004-2005 and 18.2:100 / 6.1:100 in 2005-2006. Winter 2005-2006 was longer and more severe in the Gallatin drainage than in other areas.

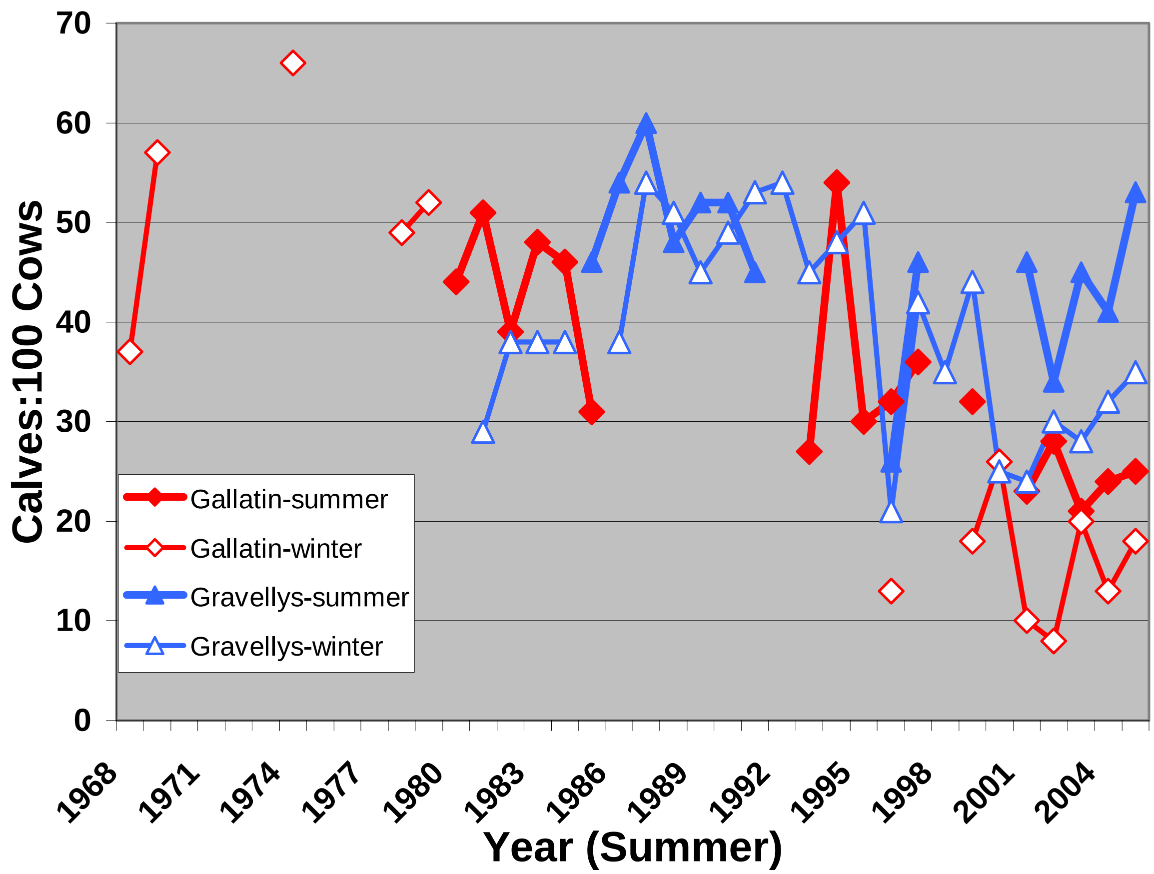

Figure 15. Mid-summer and mid-winter calf:100 cow ratios for the Gallatin and Gravelly-Snowcrest elk populations, 1968-2005.

Northern Yellowstone Elk Calf Mortality Study

An investigation of mortality rates and causes for newborn elk calves on the Northern Yellowstone Range was conducted during 1987-1990 (Singer et al. 1997) prior to wolf restoration and a follow-up study began in 2003 (Barber-Meyer 2006).

Elk calf mortality during summer (birth through October) averaged twice as high during 2003-2005 than during pre-wolf years of 1987-90 (Barber-Meyer 2006, Table 4). Winter mortality rates during the recent period were half that during 1987-1990 (Table 4) and the combination resulted in annual mortality rates about 50% higher during 2003-2005 than during 1987-1990 (Table 4).

Table 4. Mortality rate (%) of newborn elk calves, Northern Yellowstone Range, 1987-1990 and 2003-2005.

		Mortality Rate (%)		
Year[a]	No. Marked	Summer [b]	Winter [c]	Annual
1987[d]	30	44	14	52
1988[d]	29	15	84	86
1989[d]	36	32	8	38
1990[d]	32	50	6	53
TOTAL[d]	**127**	**35**	**28**	**57**
2003[e]	51	69	13	73
2004[e]	44	73	9	77
2005 [e]	56	75	8	79
TOTAL [e]	**151**	**72**	**10**	**76**

[a] Year = year of birth.
[b] Summer = mid-May (birth) through October.
[c] Winter = November – May.
[d] from Singer et al. 1997.
[e] from Barber-Meyer 2006.

The known causes of mortality averaged 95% predation during 2003-2005 compared to 72% during 1987-90 (Table 5). The increase appears to be related to an increase in mortality caused by bears of both species (Table 5, 55% grizzly bear, 35% black bear, and 10% unknown bear species). Wolf predation on elk calves during summer has been relatively minor thus far, not totally offsetting a decline in mortality caused by coyotes from levels observed during 1987-90 (Table 5). Grizzly bear numbers in the GYA have increased since 1995 (Figs. 16 and 17), possibly explaining increased mortality caused by bears.

Table 5. Cause of mortality (%) for radio-transmitter marked newborn elk calves, Northern Range, 1987-90 (Singer et al. 1997) and 2003-2005 (Barber-Meyer 2006) (**Known causes only used for percentages**).

Cause of Mortality	1987-1990 Summer		2003-05 Summer		1987-90 Winter		2003-06 Winter	
Wolf			14				25	
Bear (both species)	39		60					
Wolf or Bear			2					
Coyote	28		9				25	
Wolf or Coyote							25	
Eagle	3		1					
Mountain Lion			3		3			
Wolverine			1					
Unknown Predator	3		5					
TOTAL PREDATION	**72**		**95**		**3**		**75**	
Starvation	3				58			
Disease	8				3			
Hunter Harvest					15		25	
Accident	6				3			
Unknown/Natural[a]	13		5[a]		15			
TOTAL OTHER	**28**		**5**[a]		**97**		**25**	

[a] 2003-2005 – 1 likely drowning, 1 excess fluoride, 1 non-fully expanded lungs, 1 exposure (snowstorm), and 1 pneumonia.

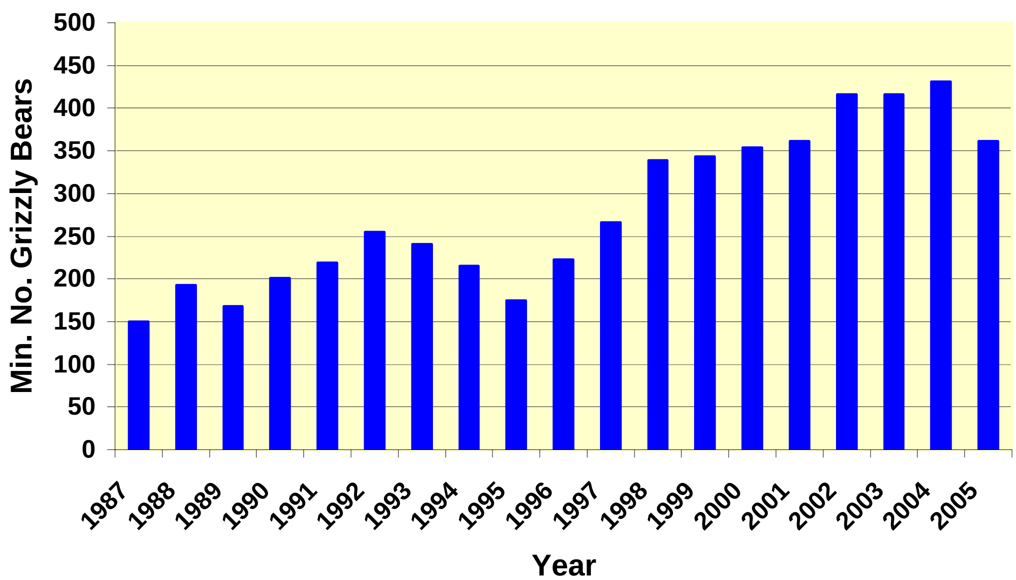

Figure 16. Minimum population estimates for Grizzly Bear, Greater Yellowstone Area, 1987-2005 (from Haroldson 2006; Haroldson & Frey 2006).

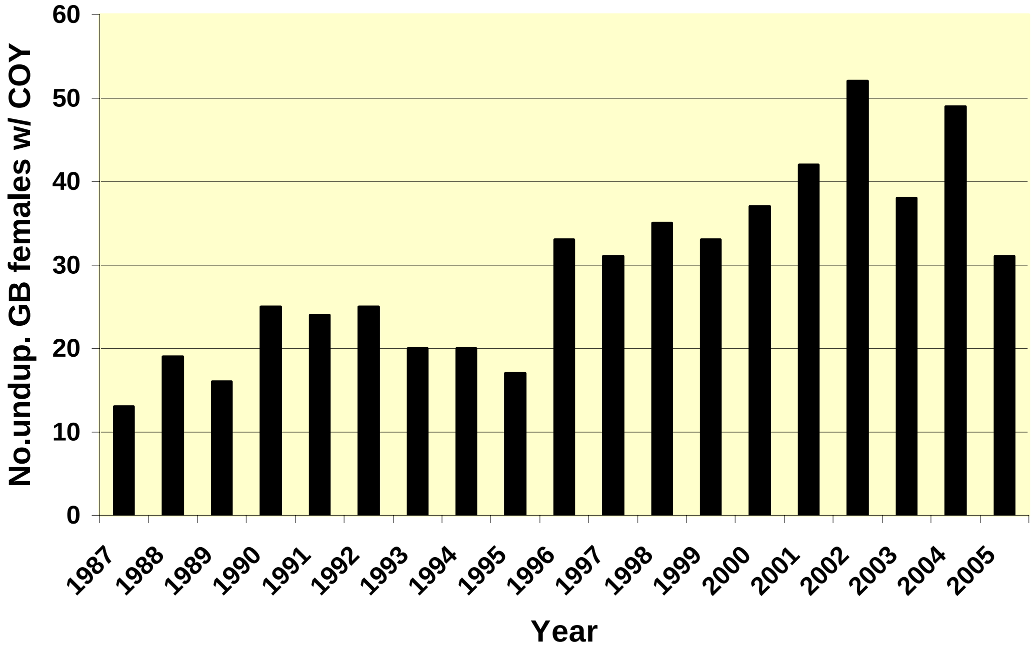

Figure 17. Unduplicated Grizzly Bear females with cubs-of-the-year, GYA, 1987-2005 (from Haroldson 2006; Haroldson & Frey 2006).

Madison-Firehole Elk Recruitment

Recent data (Fig. 18, Madison-Firehole only, Dr. R. Garrott, unpubl. data) suggests that wolves have introduced some additive winter mortality of elk calves to this population normally controlled by effects of winter severity (especially snow depth) on calf recruitment rates (Garrott et al. 2003). The information in Figure 18 indicates that, controlled for snowpack conditions, elk calf recruitment has been lower during the post-wolf period than during the pre-wolf period. This indicates some additive mortality due to wolves at SWE below 8000, however, at SWE above 8000 (Fig. 18), mortality due to wolves may become mostly compensatory to “winter-kill”.

During the past year, wolf numbers have declined on this area and the remaining wolves killed more bison and fewer elk than in the past (Dr. R. Garrott, pers. comm.). As with the Northern Yellowstone area, declining/fluctuating wolf numbers for periods of time will aid in making conclusions about wolf effects on ungulates in the ongoing “natural experiment”. Within our broad study area, hunter harvest is about the only variable that can be “controlled”. The predominance of uncontrolled variables means that data must be collected over long periods of time and even then, many will consider conclusions equivocal.

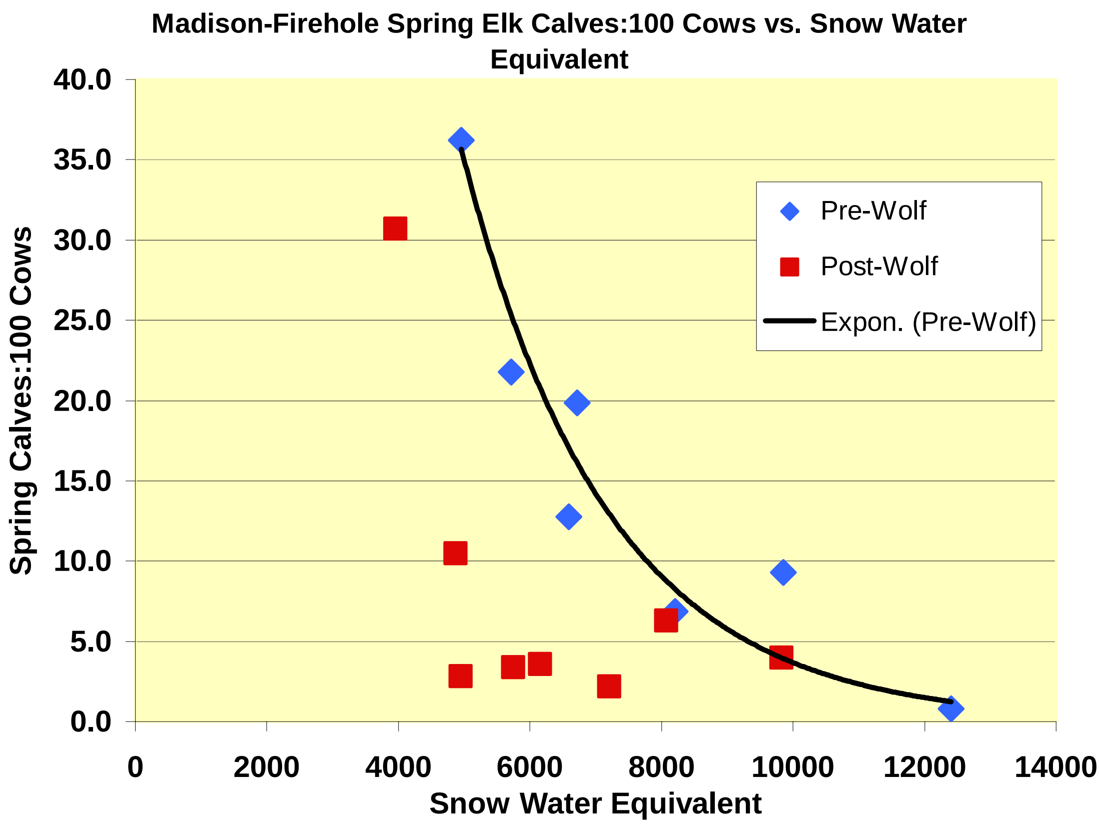

Figure 18. Elk calf recruitment in the Madison-Firehole population in relation to snowpack severity index during pre- and post-wolf periods, 1992-2006 (Figure courtesy of Dr. R. Garrott).

Offtake by Hunters and Wolves – Northern Yellowstone Elk Population

Following, I present **revised** (from those in Hamlin 2005) estimates of relative contributions of wolf predation and hunter harvest to elk population trends in the Northern Yellowstone elk population. Others have made similar estimates (White et al. 2003, White and Garrott 2005 and Vucetich et al. 2005), however some of my assumptions/estimates are different. Most other estimates (White and Garrott 2005 and Vucetich et al. 2005) have used unadjusted elk counts as the base from which to estimate offtake. I estimate actual pre-season elk numbers in all areas by adjusting counts based on available data (Singer et al. 1997, Hamlin and Ross 2002) including observability estimates, sightability, population modeling, and hunter harvest (FWP annual harvest surveys). For some years, this included using averages or ranges based on observing conditions during flights. Although any estimates are subject to question and interpretation, I believe it is important to use estimated pre-season elk numbers so that offtake estimates are not higher than reality.

I used wolf kill-rates of elk and sex/age composition of that kill were taken from the published and unpublished literature for the areas in calculations. The following wolf kill rates of elk on the Northern Range during winter were used for calculations: 0.061elk kills/wolf day (1995-2000); 0.0373 elk kills/wolf day (2001-2005, **revised** from Hamlin

2005) (Smith et al. 2004a, Smith et al. 2004b). Sex and age of kills were partitioned by observed selection (Smith et al. 2004a, Smith et al. 2004b). Other estimates used a winter period of October-May (White and Garrott 2005) and a summer (June-September) kill rate of 70% of the winter kill rate based on estimates by Messier (1994). I used a winter period of November-April and a kill rate of 50% of the winter rate (Geode pack – summer, Smith 2004b) for the period of May-October (**revised** from 25% during June-September in Hamlin 2005).

Numbers of wolves using the area were based on published reports and sometimes modified based on personal communications with field researchers (Smith et al. 2004a, Smith et al. 2004b, USFWS et al. 1999-2006).

Total wolf-kill estimates (Table 6) do NOT include calves from birth through September. Estimated kill is calculated by multiplying kill rate (kills/wolf day) partitioned into sex and age classes and partitioned into time period times number of wolves using the area.

Regular and late season hunter harvest was estimated based on Montana's hunter harvest questionnaire. In contrast to most other estimates, I incorporated estimates of crippling loss in the total using estimates from Hamlin and Ross (2002). Total harvest **including** crippling loss (**revised**) was 1.1 times reported harvest for females and 1.05 times reported harvest for males (**revised** from 1.2 and 1.1, respectively in Hamlin 2005 because of more open terrain and controlled hunt in Gardiner area compared to Gravelly-Snowcrest Mountains).

Estimates of offtake in Tables 6 are dependent on published/unpublished estimates of the individual component data. Given the incorporation of estimated "true" elk population size and hunter crippling loss, I believe the estimates to be relatively accurate. Compared to other estimates, estimates here are probably inherently biased a little high for hunter offtake and a little low for wolf offtake.

For the Northern Range, estimated wolf numbers were 32, 42, 44, 72, 77, 87, 106, 84, and 54 wolves for 1997-98 through 2005-06 (Smith et al. 2004a, Smith et al. 2004b, USFWS et al. 2006). The results indicating offtake by wolves (Table 6) are highly influenced by these numbers because that is the factor changing annually in the calculations (kill rate was different for 2 periods, however). Wolf-kill of male elk has been higher than hunter-kill every year since 2000-2001(Table 6, Fig. 19). Wolf-kill of female elk has equaled or exceeded hunter-kill since 2003-2004 (Table 6, Fig. 20). Total estimated offtake by wolves has exceeded offtake by hunters during the last 4 years in numbers and percentages (Table 6, Figs. 19, 20, and 21). Although estimated kill of elk by wolves has declined in the last 2 years due to declining numbers of wolves on the Northern Range, kill of elk by hunters has declined at a greater rate (Table 6, Figs. 19, 20, and 21).

Table 6. Estimated number and percentage of pre-season (15 Oct.) Northern Yellowstone elk population harvested by hunters and killed by wolves, 1985-1992 and 1997-2006. Male and female columns each include one-half of calves. **Does not include newborn calves, birth - 15 October.**

Year	Est. No. Elk Pre-season[a]	♂♂- Hunter Harvest[b,d]	♂♂- Wolf-kill[c,d]	♀♀ - Hunter Harvest [b,d]	♀♀ - Wolf-kill[c,d]	Total Hunter Harvest[d]	Total Wolf-kill[d]	Total HK+WK[d]
1985-86	22,662	605 (8.5)	-	968 (6.2)	-	1,573 (6.9)	-	1,573 (6.9)
1986-87	20,398	648 (11.8)	-	748 (5.0)	-	1,396 (6.8)	-	1,396 (6.8)
1987-88	21,852	263 (4.4)	-	243 (1.5)	-	506 (2.3)	-	506 (2.3)
1988-89	21,299	688 (11.4)	-	2,344 (15.4)	-	3,032 (14.2)	-	3,032 (14.2)
1989-90	18,241	376 (8.2)	-	434 (3.2)	-	810 (4.4)	-	810 (4.4)
1990-91	18,336	394 (9.3)	-	688 (4.9)	-	1,082 (5.9)	-	1,082 (5.9)
1991-92	21,625	2,696 (34.4)	-	1,623 (13.0)	-	4,319 (20.0)	-	4,319 (20.0)
Pre-wolf Mean	**20,630**	**810 (12.6)**	**-**	**1,007 (7.0)**	**-**	**1,817 (8.8)**	**-**	**1,817 (8.8)**
1997-98	15,574	426 (6.6)	220 (4.0)	1,229 (13.4)	259 (3.1)	1,655 (10.6)	479 (3.1)	2,134 (13.7)
1998-99	15,676	462 (7.9)	287 (6.5)	1,592 (16.2)	340 4.0)	2,054 (13.1)	627 (4.0)	2,681 (17.1)
1999-00	19,103	286 (3.9)	302 (4.7)	877 (7.5)	356 (3.3)	1,163 (6.1)	658 (3.4)	1,821 (9.5)
2000-01	17,782	449 (6.3)	493 (8.6)	1,152 (10.8)	580 (6.2)	1,601 (9.0)	1,073 (6.0)	2,674 (15.0)
2001-02	15,793	310 (6.1)	452 (10.3)	1,042 (9.7)	522 (5.2)	1,352 (8.6)	974 (6.2)	2,326 (14.7)
2002-03	12,306	314 (11.6)	511 (23.5)	743 (7.7)	590 (6.5)	1,057 (8.6)	1,101 (8.9)	2,158 (17.5)
2003-04	11,160	245 (9.5)	622 (30.6)	664 (7.8)	717 (9.0)	909 (8.1)	1,339 (12.0)	2,248 (20.1)
2004-05	12,621	240 (9.2)	342 (16.8)	444 (4.4)	427 (4.5)	684 (5.4)	769 (6.1)	1,453 (11.5)
2005-06[e]	12,694	209 (7.1)	279 (14.8) [e]	114 (1.2)	352 (4.0) [e]	323 (2.5)	631 (5.0)	954 (7.5)
Post-wolf Mean	**14,745**	**327 (7.6)**	**390 (13.3)**	**873 (8.7)**	**460 (5.1)**	**1,200 (8.0)**	**850 (6.1)**	**2,050 (14.1)**

[a] Estimated based on population reconstruction, sightability, and harvests. Data from Singer et al. (1997) used and also applied to counts from 1997-2005. When counts were not made, estimates extrapolated from existing data.

[b] Hunter harvest estimates from Statewide harvest questionnaire, check station and also includes estimates for crippling loss- data from Hamlin and Ross (2002) reduced by half because of more open terrain & controlled hunt– Total harvest including crippling loss = 1.1x reported harvest for females and 1.05x reported harvest for males. Male and Female columns each include one-half of calves 5-months & older.

[c] Wolf kill estimates based on reported wolf numbers on the Northern Range, published kill rates partitioned among adult males, adult females, and calves as observed, and partitioned among 3 time periods (see description in text) (also see Smith et al. 2004a, 2004b, and USFWS et al. 2004).

[d] Number (percent of estimated pre-season population).

[e] Assumes 2001-2004 kill rates.

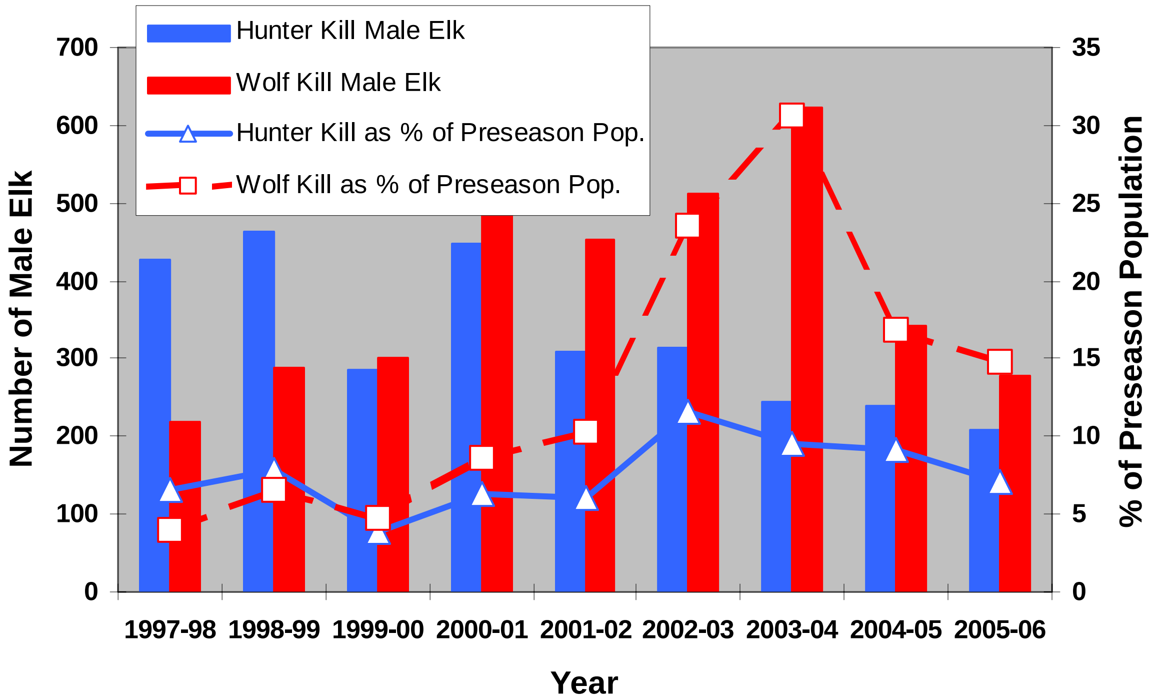

Figure 19. Estimated numbers and percentages of the pre-season Northern Yellowstone male elk population killed by hunters and wolves, 1997-1998 through 2005-2006.

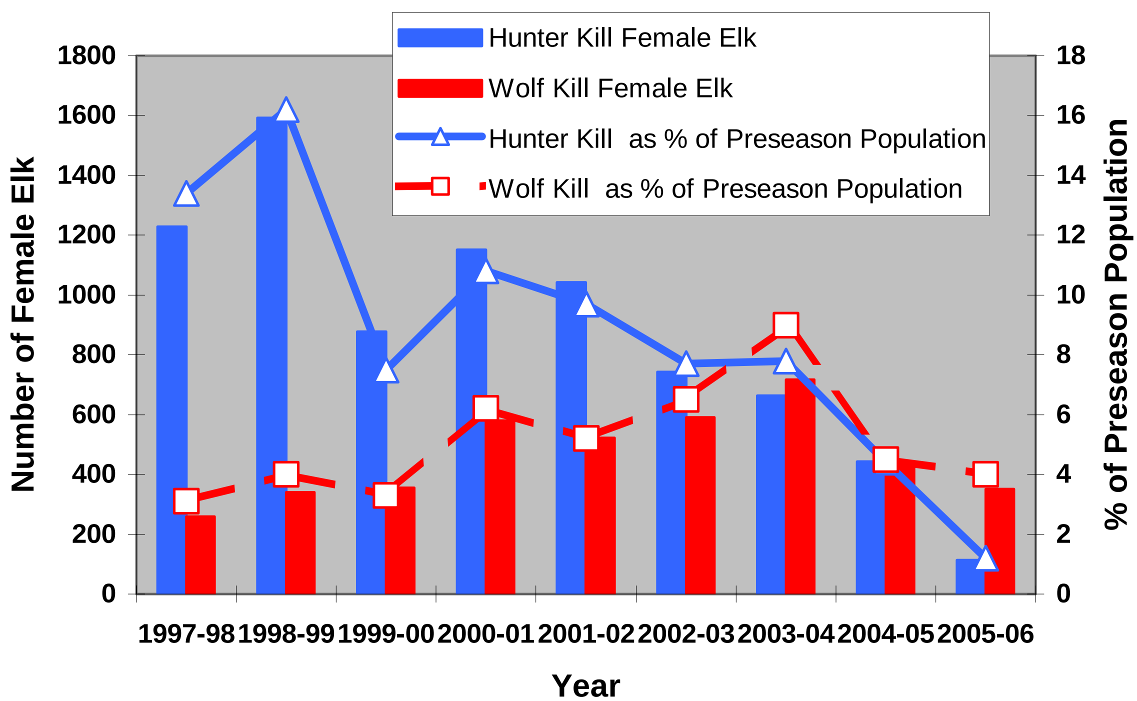

Figure 20. Estimated numbers and percentages of the pre-season Northern Yellowstone female elk population killed by hunters and wolves, 1997-1998 through 2005-2006.

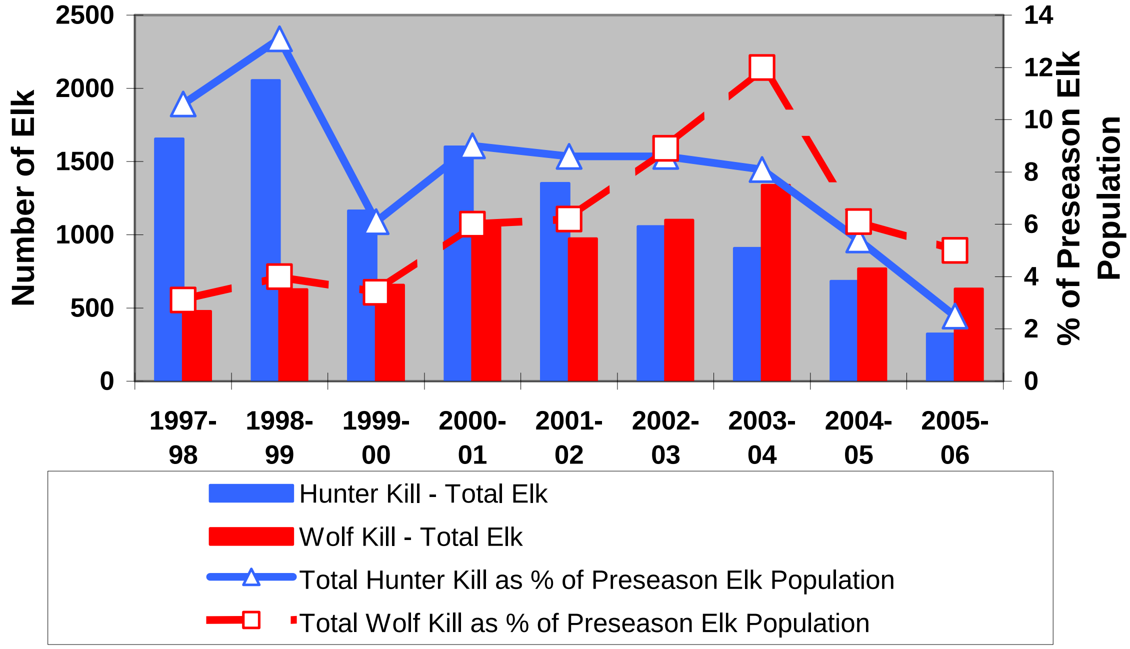

Figure 21. Estimated numbers and percentages of the pre-season Northern Yellowstone total elk population killed by hunters and wolves, 1997-1998 through 2005-2006.

Total offtake, including both hunters and wolves, has averaged about 6% higher during the post-wolf years of 1997-98 through 2005-06 than during the pre-wolf years of 1985-86 through 1991-92. The pre-wolf period included heavy hunter harvest during 1988-89 and 1991-92 and also heavy winter loss during 1988-89. Despite this heavy hunter harvest and winter-kill, the elk population recovered from these events, reaching a historical high of 19,045 counted elk in 1993-1994 (Figs. 9 and 11). During 1985-1996, calf recruitment averaged 33 calves:100 cows, ranging from 19-48 calves:100 cows (Fig. 14). The decline in counted elk (Figs. 9 and 11) began after high winter mortality during 1996-1997 and high hunter harvest of females during 1997-1998 and 1998-1999 intended by MFWP to reduce the number of elk wintering in Montana, outside YNP. During 1994-2005, the elk population declined without recovery (Figs. 9 and 11). During this period, recruitment averaged only 19 calves:100 cows and during 2002-2005 calf recruitment ranged between 12-14 calves 100 cows (Fig. 14).

Although the number of elk killed by hunters declined after 1999, kill of elk by wolves increased (Figs. 19, 20, and 21). Both the level of increased total offtake (Table 8, including increasing wolf-kill after 1995 and reduced hunter harvest after 1999) and reduced recruitment contributed toward elk population decline/lack of recovery. The decline in elk calf recruitment during 1995-2006 compared to the pre-wolf period is a major contributor to observed population status (Figs. 22 and 23). Preliminary modeling indicates that the following factors contributed to the recent lower level of elk calf recruitment: 1.) 29% contribution -fewer breeding cows (resulting from winter mortality in 1996-97 and high hunter harvests in 1997-99; 2.) 56% contribution –increased neonatal mortality (increased predation – primarily bears) and; 3.) 15% contribution – increased winter mortality (primarily wolves).

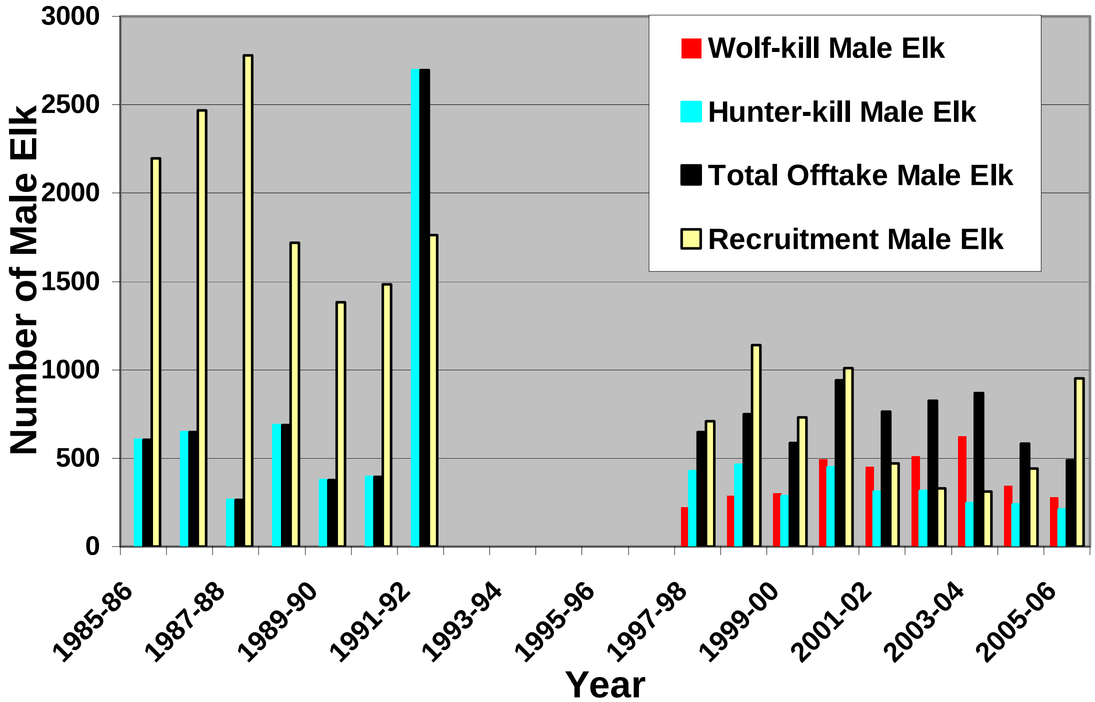

Figure 22. Estimated numbers of male elk (6 months and older) killed by hunters and wolves and estimated numbers of male elk recruited during 1985-86 through 2005-06.

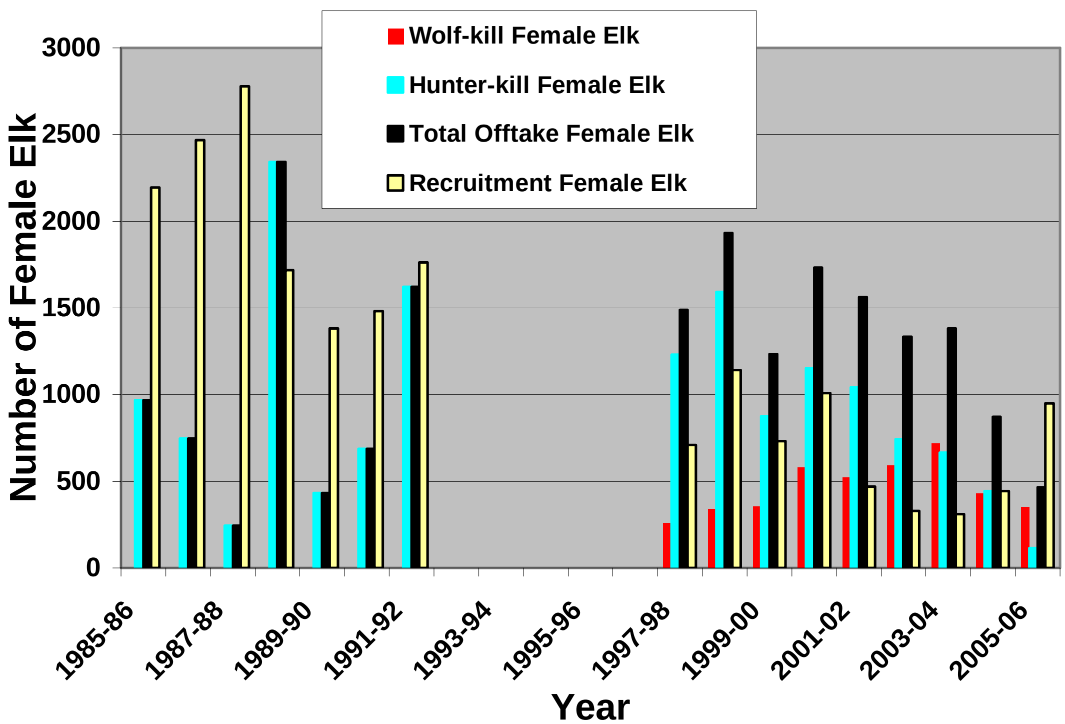

Figure 23. Estimated numbers of female elk (6 months and older) killed by hunters and wolves and estimated numbers of female elk recruited during 1985-86 through 2005-06.

Extensive Studies – Montana beyond the GYA

Garnet Mountains Study

As part of a FWP cougar study, newborn elk calves were captured and marked with radio-transmitter collars during 2002-2004 in the Garnet Mountains (Raithel 2005). Mortality through 31 August was much higher for the sample in 2002 (71%) than in 2003 (11%) or 2004 (14%) (Raithel 2005). For the 3 years combined, 25 of 98 (26%) non-censored elk calves died during summer. For 2002, the radio-collared sample indicated higher mortality than indicated by subsequent classifications of the entire population. For 2003 and 2004, subsequent classifications indicated additional mortality beyond that indicated by the radio-collared sample.

Of 25 total summer mortalities during the entire period, 10 (40%) were attributed to black bear predation, 3 (12%) to cougar predation, 1 (4%) to coyote predation, 1 (4%) to unknown canid predation, 2 (8%) to unknown predators, and 8 (32%) to malnutrition/disease (Raithel 2005). Sixty-eight percent of summer mortality was attributed to predation and for this area without grizzly bears or an established wolf pack, black bears accounted for 40% of total summer calf mortality.

During fall, 3 (5.1%) of 59 elk calves died. Cougar predation, legal harvest, and unknown causes each contributed one mortality. Mortality of adult cow elk was low, averaging 8.7% during 2002-2004 (Raithel 2005).

This study has continued with Nyeema Harris as the new graduate student (Dr. Dan Pletcher advisor). During 2005, 49 newborn elk calves were captured and marked. Ten (22%) of 46 uncensored calves died by 1 September (Harris, pers. comm.). Causes of mortality were black bear predation (10%), cougar predation (30%), unknown predator (10%), malnutrition/disease (20%), fence entanglement (10%), and unknown (10%) (Harris, pers. comm.). The 25% summer mortality rate for 4 years (35 mortalities of 144 uncensored calves) is substantially lower than observed in the Northern Yellowstone Range (72%, Barber-Meyer 2006) or Gallatin Canyon (45-52%, this report). During May and early June 2006, an additional 51 newborn elk calves were captured and marked on the Garnet study area (Harris, pers. comm.).

Statewide

Census and trend flights of ungulates recording numbers observed and sex and age ratios continue to be conducted by Area Management biologists throughout Montana. These include areas with a wide spectrum of varying densities of predators, hunter harvest, weather conditions, and other factors. Similarly, we continue to collect elk calf:100 cow classifications in mid-summer in the North Bridger Mountains, Elkhorn Mountains, Bitterroot/Big Hole, and Sun River areas in addition to areas described earlier in this report. Future reports will contain analyses and summaries of this extensive data in comparison to data from southwestern Montana.

Research and Management Data Needs

In the last report (Hamlin 2005) I discussed research and management data needs relative to the extensive scale Wolf-Ungulate Project. Since that time I have explored methods of monitoring abundance of uncommon, more secretive, or low-density species such as moose, black and grizzly bear, mountain lions, and wolves that would not involve full-time intensive work over the state. Below, I present results from hunter observations reported at the Gallatin Canyon check station for grizzly bear and wolves (Fig. 24) and moose (Fig. 25). Although more hunters may observe tracks than animals when conditions are advantageous (snow and mud), the variability of these conditions among years is problematic. Direct observations of animals are fewer, but may be more comparable among years. It is unlikely that this type of observational data will be useful for year-to-year comparisons, but may be useful when comparing broad periods of time (such as 1989-1993 compared to 2000-2005, Fig. 24). A further step will be to compare this observational data to information from any intensive research information on nearby areas. In the broad comparison periods mentioned above, the hunter observational data agree with other more substantive research data.

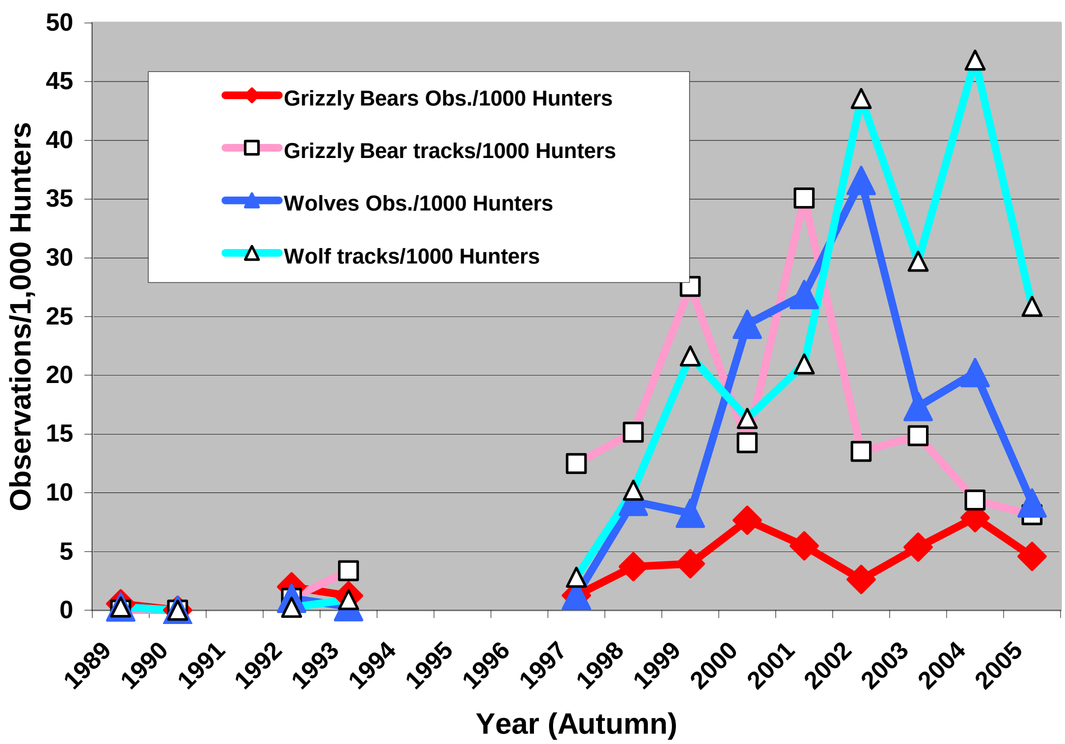

Figure 24. Observations of Grizzly Bears, Grizzly Bear Tracks, Wolves, and Wolf Tracks per 1,000 Hunters, Gallatin Canyon Check Station.

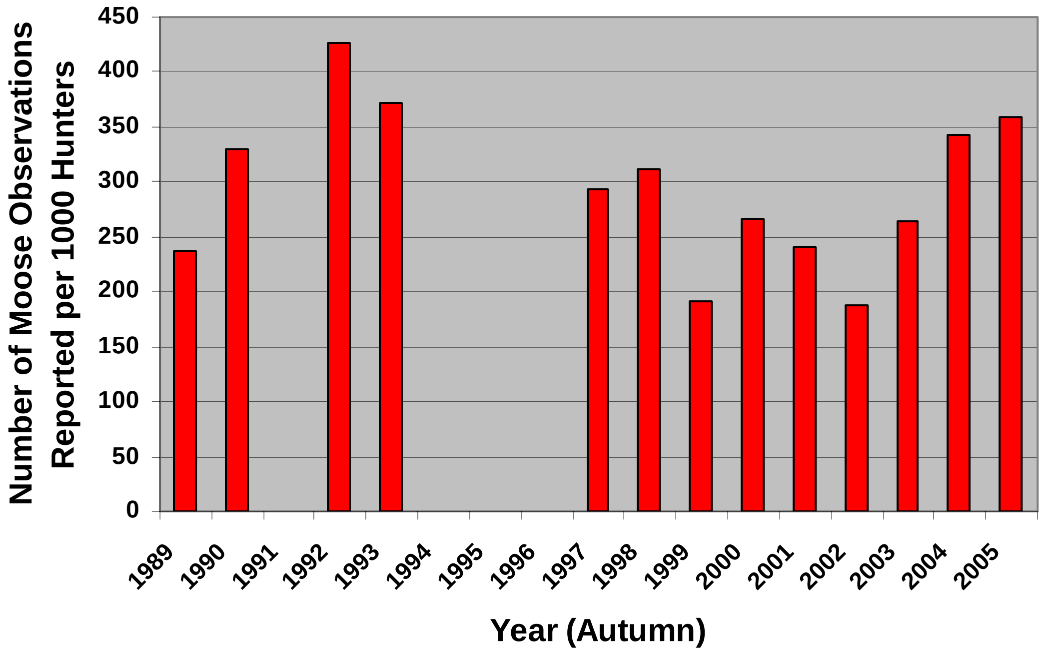

Figure 25. Observations of Moose per 1,000 Hunters, Gallatin Canyon Check Station.

Similarly, other consistently collected observational data appears to verify what we "know" about grizzly bear and moose numbers in the Gallatin Canyon area. Records of all species observed while conducting radio-relocation flights for elk were recorded during 1972-1977 and 2001-2005 in the Gallatin-Madison Ranges. Data from flights conducted during April through October (Table 7) indicated fewer moose and more grizzly bear observed during 2001-2005 compared to 1972-1977 and similar numbers of black bear.

Table 7. Numbers of moose, grizzly bear, and black bear observed during aerial radio-relocation flights (April-October) in the Gallatin-Madison Ranges, 1972-77 and 2001-05

	Moose		Grizzly Bear		Black Bear	
	Moose (Flights)	Moose/Flight	Gr.Bear (Flights)	Gr. Bear/Flight	B. Bear (Flights)	B. Bear/Flight
1972-1977	177(56)	3.16	15 (56)	0.27	40 (56)	0.71
2001-2005	59 (35)	1.69	54 (35)	1.54	25 (35)	0.71

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